REPORT

OF

COLUMBIA RIVER TREATY

CANADIAN AND UNITED STATES ENTITIES

for the Period

1 October 1976

to

30 September 1977

November 1977

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INTRODUCTION

This report describes the joint actions of the Canadian and United States Entities during the period 1 October 1976 through 30 September 1977 in discharging their responsibilities for formulating and carrying out operating arrangements necessary to implement the Columbia River Treaty. It is the eleventh of a series covering the period since the ratification of the Columbia River Treaty in September 1964.

ORGANIZATION AND MEETINGS

The names of the members and representatives of the two Entities during the reporting period are shown in Appendix A. There was one regular meeting of the Entities and one meeting of the Canadian Entity Representative and United States Coordinators.

The two international committees, listed in Appendix B, met as required throughout the reporting period to direct and coordinate Treaty storage operations and studies with the support of the staffs of British Columbia Hydro and Power Authority, Bonneville Power Administration, and the U.S. Corps of Engineers, North Pacific Division.

COLUMBIA STORAGE OPERATION

Operating Arrangements

During the period covered by this report, Duncan, Arrow, Mica, and Libby reservoirs were operated in accordance with the Columbia River Treaty for power and flood control.

The Canadian entitlement to downstream power benefits from Duncan, Arrow, and Mica for the 1976-77 operating year had been purchased in 1964 by the Columbia Storage Power Exchange. In accordance with the Canadian Entitlement Exchange Agreements dated 13 August 1964, the United States Entity delivered capacity and energy to the CSPE participants.

The operation of the storages was generally in accordance with:

(a) "Columbia River Treaty Hydroelectric Operating Plan - Assured Operating Plan for Operating Year 1976-77" dated January 1972.

(b) "Detailed Operating Plan for Columbia River Treaty Storage - 1 August 1976 through 31 July 1977" dated September 1976.

(c) "Columbia River Treaty Flood Control Operating Plan" dated October 1972.

Since generators were installed at Mica during the 1976-77 operating year, the Detailed Operating Plan was the first such plan designed to achieve optimum power generation at-site in Canada and downstream in Canada and the United States, in accordance with paragraph 7 of Annex A of the Treaty. All previous

DOP's had been prepared in accordance with paragraph 6 which provides for optimum power generation downstream in the United States. Similarly, the 1977-78 DOP was designed to achieve optimum power generation in both countries. Accordingly, 1.5 MW of capacity and 5.5 MW of energy are being delivered from B.C. Hydro to the U.S. Entity during the period 1 April 1977 to 31 March 1978.

Attached to this report as Appendix D is "Annual Report on Operation of Columbia River Treaty Projects - 1 August 1976 through July 1977" dated ~~September~~ OCTOBER 1977. Appendix D reports in detail on the runoff conditions prevailing and on the operation of the Treaty storages for the first 10 months of the 12-month period of this report.

A brief summary follows of the Columbia River Treaty operation of the Mica, Arrow, Duncan and Libby reservoirs during the period 1 October 1976 to 30 September 1977.

General

Cool, wet weather prevailed throughout the Columbia River Basin in August 1976 and the Columbia River Treaty reservoirs were maintained near full pool levels through August and September. In September a stable upper air wave pattern and an almost stationary high pressure ridge moved over the Basin. This resulted in one of the driest fall and winter seasons on record. The October through April precipitation for the various drainage areas in the Basin ranged from 80 percent of normal in the upper Columbia River drainage area to less than 25 percent of normal in eastern Oregon, central Washington, and southwestern Idaho. By 1 April 1977 the Basinwide snow accumulation was only 50 percent of normal and the resulting April-August runoff volume at The Dalles was the lowest in 50 years of record.

Operation of the reservoirs for flood control was not a factor during the spring runoff in 1977. Without any regulation by upstream reservoirs, the peak flow at The Dalles would have been only 276,000 cfs, substantially lower than the bank full capacity of 450,000 cfs. The observed maximum daily flow at The Dalles was only 184,300 cfs.

The impact of the drought on power operations was substantial. BPA curtailed secondary energy sales to the southwest utilities on 13 September 1976, to industrial customers and private utilities on 1 November, and to public agencies on 1 December. However, the industrial customers continued to find a power supply from numerous sources for their nonfirm load, but in decreasing amounts over time. Between November 1976 and early July 1977, this load was reduced by about 68 percent.

United States and Canadian reservoirs failed to refill by 31 July 1977 in the amount of 12.7 MAF or 14.1×10^9 kWh, a deficiency of about 30 percent of the total usable storage energy. About 1.4 MAF of the refill deficiency was attributed to a program for release of water from U.S. reservoirs to aid the downstream migration of anadromous smolts during the period 9 May through 17 June. This loss in reservoir storage included actual water spilled and overgeneration that was stored in Pacific Southwest utilities for potential return at a later date.

The effect of the drought on power operations was mitigated by loads underrunning estimates. BPA firm energy load underran the estimates 5 to 7 percent each month of the operating year due to generally mild weather, depressed economic conditions, and conservation efforts. Total Northwest loads underran 2 to 8 percent.

Because of the power shortage in the U.S. Pacific Northwest resulting from the extremely low streamflows, the Entities agreed in February 1977 to an "Emergency Draft Arrangement" under which the Canadian Entity drafted additional Canadian storage prior to 30 April 1977 to generate 600 million kilowatthours of emergency energy at downstream U.S. Federal projects. Following the emergency releases, B.C. Hydro restored the Arrow and Duncan reservoirs to the levels they otherwise would have reached by releasing additional water from McNaughton Lake. The U.S. Entity paid B.C. Hydro a fee based on the amount of emergency energy generated. In addition, it will make up the reduction in McNaughton Lake storage by 31 July 1979 and will compensate B.C. Hydro for generating losses at the Mica powerplant.

McNaughton Lake

McNaughton Lake was at elevation 2474.5 feet on 1 October 1976. The reservoir discharges during the period from early October through November were generally in accordance with monthly average outflows specified in the Detailed Operating Plan. Units 1 and 2 at the Mica powerplant were commissioned during mid-December. The plant was then operated without spill, discharging approximately 20,000 cfs, except for periods of unit inspection and maintenance, until late March when the third unit went into commercial operation. Thereafter, discharges ranged from 17,000 cfs to 30,000 cfs through the period ending 30 September and were above the reservoir discharge requirements to restore the Arrow and Duncan reservoirs under the Emergency Draft Arrangement.

The McNaughton reservoir was at its lowest elevation of 2414.6 feet on 29 April and reached its maximum elevation during the 1977 refill period of 2455.5 feet on 27 August. The McNaughton Lake elevation was 2451.6 feet on 30 September.

Arrow Reservoir (Keenleyside Dam)

The Arrow Reservoir was at elevation 1445.4 feet on 1 October 1976. Beginning on 16 October the reservoir was drafted to meet downstream power requirements. By the end of January it was 5 feet below the Critical Rule Curve and the reservoir continued to be drafted below its rule curve to provide emergency energy under the Emergency Draft Arrangement. The reservoir reached a low point of 1387.8 feet on 9 April. Because of the extremely low 1977 snowmelt runoff, Arrow reservoir peaked at 1410.9 feet on 27 June, 33 feet below its normal full pool elevation.

Under an agreement between Bonneville Power Administration and B.C. Hydro, during the period from June through September energy was delivered by B.C. Hydro to BPA in lieu of a portion of the requested storage draft from Arrow reservoir. By the end of September about 0.76 million acre-feet of water had been retained through this measure and resulted in partial improvement in reservoir levels for recreation and navigation purposes. On 30 September, Arrow was at elevation 1397.3 feet.

Duncan Reservoir

Duncan was at elevation 1891.5 feet on 1 October 1976. Commencing 1 October the reservoir was drafted at rates up to 10,000 cfs and it reached its normal minimum pool elevation of 1794.3 feet on 22 March. The reservoir discharges were held at 100 cfs from 30 March until the reservoir reached full pool elevation of 1892 feet on 14 August. Reservoir drafts commenced shortly thereafter and by 30 September the reservoir elevation was 1875.3 feet.

Lake Koocanusa

Lake Koocanusa was held near full pool until late September and was at elevation 2457 feet on 30 September. Significant reservoir drawdown began in early October and proceeded through the winter, meeting mandatory Upper Rule Curve points and providing power generation. Inspection of the stilling basin at Libby Dam in November indicated serious erosion had occurred, and steps were initiated to effect its repair. On 26 April the reservoir reached its lowest level for the year, elevation 23~~4~~58.5 feet.

During the refill period in May and early June the project released near-minimum outflows, which helped offset system overgeneration resulting from the "Fish Flow 1977" operation. In late June outflow was increased to meet system load requirements. Lake Koocanusa reached its maximum elevation of 2415 feet on 6 July, 44 feet below full pool. Repairs began on the stilling basin during August and the work is scheduled to be completed in February 1978. By the end of September the lake was at elevation 2411 feet.

COMMITTEE ACTIVITIES

Hydrometeorological Committee

The Hydrometeorological Committee prepared the document "Columbia River Treaty - Hydrometeorological System Plan for Exchange of Operational Hydromet Data" dated 30 September 1976. The document was approved by the Entities effective 22 March 1977 and is expected to be in force until 31 July 1978.

The Committee continued to study the development and use of the Columbia River Treaty hydrometeorological system. In December 1976 the Corps of Engineers awarded a major contract that includes the installation of the Columbia River Operational Hydromet Management System (CROHMS) central computer facility. This facility will form a central data bank capable of serving water management agencies in the Northwest. The Committee is exploring the possibility of linking the Canadian Section with this facility.

During the spring runoff season, aerial snow reconnaissance flights were made by both Sections to provide snow cover data that is utilized in runoff forecast models. These data are supplemented by satellite snow cover data prepared by the Environmental Products Group of the U.S. National Oceanic and Atmospheric Administration.

Operating Committee

In accordance with its terms of reference, the Operating Committee was responsible through the year for implementing the current hydroelectric and flood control operating plans for the storage provided in Canada under the Columbia River Treaty. This aspect of the Committee's work is described in Appendix D, "Annual Report on Operation of Columbia River Treaty Projects - 1 August 1976 through July 1977", dated ~~September~~ OCTOBER 1977.

Three Entity agreements were concluded and signed on 17 October 1977:

Assured Operating Plan for Operating Year 1982-83;

Determination of Downstream Power Benefits for Operating Year 1982-83; and

Detailed Operating Plan, 1 August 1977 through 31 July 1978.

The Entities discussed some of the outstanding issues yet to be resolved in a revised draft of the Principles and Procedures for the Preparation and Use of Hydroelectric Operating Plans for Canadian Treaty Storage dated 25 July 1967. The issues were referred to the Operating Committee and the completion of the revised draft will be a high priority item on the Committee's agenda during the coming year.

COOPERATION WITH PERMANENT ENGINEERING BOARD

The Entities continued their cooperation with the Permanent Engineering Board in the discharge of its functions and a joint meeting of the Permanent Engineering Board and the Entities was held on 16 November 1976 in Portland, Oregon, U.S.A.

Copies of the agreements listed in Appendix C were sent to the Board.

APPENDIX A

COLUMBIA RIVER TREATY ENTITIES

CANADA

ROBERT W. BONNER
CHAIRMAN

Chairman
British Columbia Hydro and
Power Authority
Vancouver, B.C.

Canadian Entity Representative

DOUGLAS R. FORREST *

Manager
Canadian Entity Services
British Columbia Hydro and
Power Authority
Vancouver, B.C.

UNITED STATES OF AMERICA

DONALD PAUL HODEL
CHAIRMAN

Administrator
Bonneville Power Administration
Department of the Interior
Portland, Oregon

MAJOR GENERAL WESLEY E. PEEL

Division Engineer
North Pacific Division
Corps of Engineers, U.S. Army
Portland, Oregon

United States Entity Coordinators

HAROLD KROPITZER
COORDINATOR

Executive Assistant to the
Administrator
Bonneville Power Administration
Portland, Oregon

PHILLIP L. COLE
COORDINATOR

Chief, Engineering Division
North Pacific Division
Corps of Engineers, U.S. Army
Portland, Oregon

CHARLES E. CANCILLA
Secretary

Bonneville Power Administration
Portland, Oregon

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* Succeeded P. Ralph Purcell, 5 March 1977

APPENDIX B

COLUMBIA RIVER TREATY

INTERNATIONAL COMMITTEES

The official membership of the two International Committees during the year 1 October 1976 through 30 September 1977 was as follows:

OPERATING COMMITTEE

Canadian Section	United States Section
T. J. NEWTON * Chairman	D. M. ROCKWOOD (A) Co-Chairman
W. E. KENNY	K. D. EARLS (B) Co-Chairman
R. D. LEGGE	G. G. GREEN (A)
	C. E. CANCILLA (B)

HYDROMETEOROLOGICAL COMMITTEE

Canadian Section	United States Section
U. SPORNS Chairman	D. D. SPEERS (A) ** Chairman
P. E. FAWKES	J. P. DILLARD (B) ***

All Candian committee members represent British Columbia Hydro and Power Authority. United States committee members represent either (A) United States Corps of Engineers, or (B) Bonneville Power Administration.

* Succeeded D.R. Forrest, 5 March 1977
** Succeeded F.A. Limpert, March 1977
*** Succeeded D.D. Speers, March 1977

REPORT ON

OPERATION OF COLUMBIA RIVER
TREATY PROJECTS

1 AUGUST 1976 THROUGH 31 JULY 1977

COLUMBIA RIVER TREATY OPERATING COMMITTEE

K. D. Earls
Bonneville Power Administration
Co-Chairman, U.S. Section

D. M. Rockwood
Corps of Engineers
Co-Chairman, U.S. Section

C. E. Cancilla
Bonneville Power Administration
Member, U.S. Section

G. G. Green
Corps of Engineers
Member, U.S. Section

T. J. Newton
B.C. Hydro and Power Authority
Chairman, Canadian Section

R. D. Legge
B.C. Hydro and Power Authority
Member, Canadian Section

W. E. Kenny
B.C. Hydro and Power Authority
Member, Canadian Section

REPORT ON

OPERATION OF COLUMBIA RIVER TREATY PROJECTS

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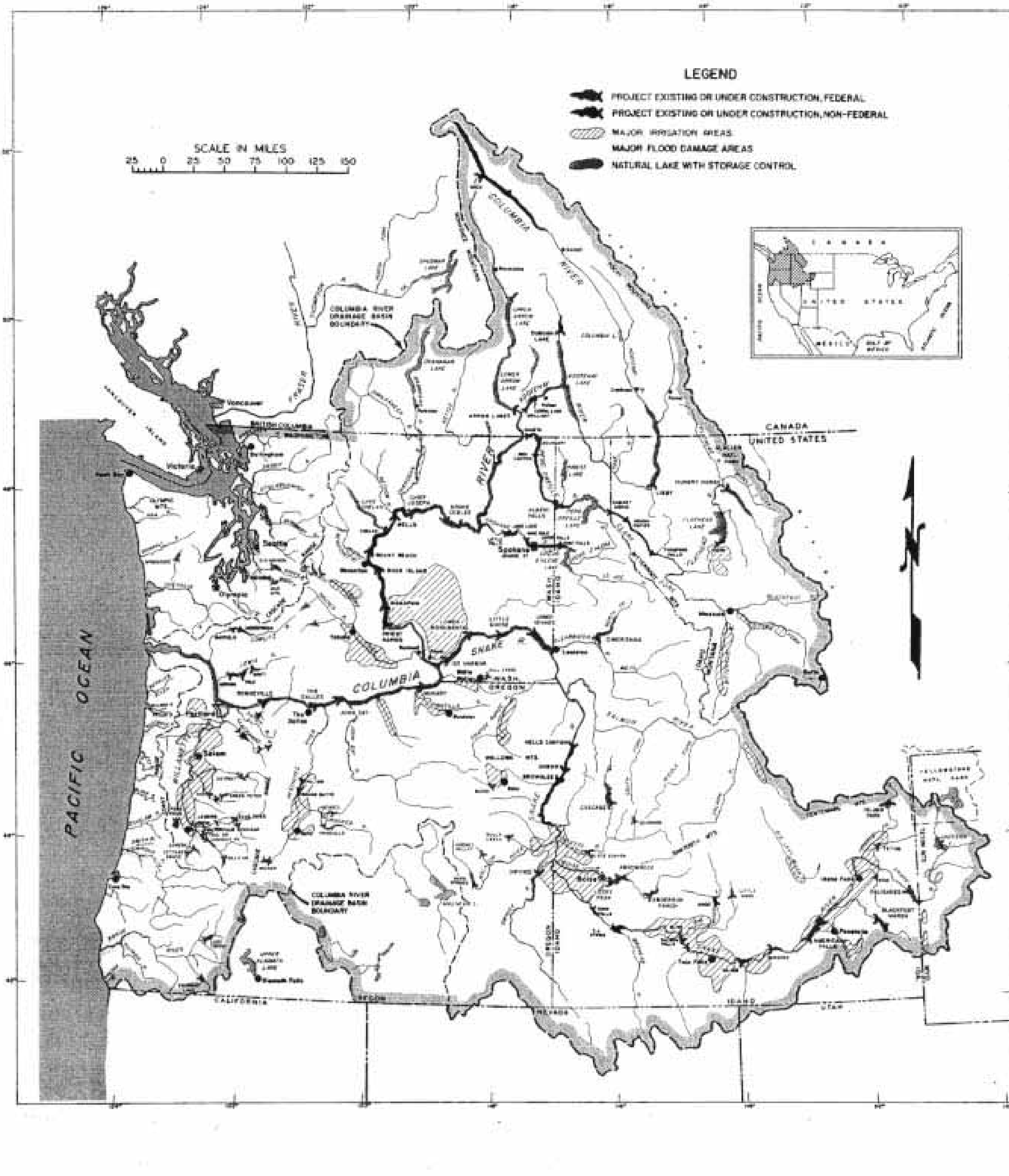
COLUMBIA RIVER AND COASTAL BASINS



REPORT ON

OPERATION OF COLUMBIA RIVER TREATY PROJECTS

1 AUGUST 1976 THROUGH 31 JULY 1977

I. INTRODUCTION

A. AUTHORITY

Duncan, Arrow, and Mica (McNaughton) reservoirs in Canada and Libby reservoir in the United States of America were constructed under the provisions of the Columbia River Treaty of January 1961. Treaty Storage is required to be operated for the purpose of increasing hydroelectric power generation and flood control in the United States of America and in Canada. In 1964, the Canadian and United States governments each designated an Entity to formulate and carry out the operating arrangements necessary to implement the Treaty. The Canadian Entity is British Columbia Hydro and Power Authority; the United States Entity is the Administrator, Bonneville Power Administration and the Division Engineer, North Pacific Division, Corps of Engineers.

The Columbia River Treaty Operating Committee, established in September 1968 by the Entities, is responsible for preparing and implementing operating plans as required by the Columbia River Treaty. This report records and reviews the operation of McNaughton, Arrow, Duncan, and Libby reservoirs for power and flood control during the period 1 August 1976 through 31 July 1977, including the major effects downstream in Canada and in the United States of America.

B. OPERATING PROCEDURE

Throughout the period covered by this report, storage operations were implemented by the Operating Committee in accordance with the Detailed Operating Plan for Columbia River Treaty Storage, dated September 1976. During the drawdown season from mid-August 1976 to late April 1977 the regulation of the Canadian Treaty storage content was normally determined by the Operating Committee on a weekly basis. As a result of this year's low runoff, the storage operations during the refill period were also determined on a weekly basis.

II. WEATHER AND STREAMFLOW

A. WEATHER

The weather in August 1976 was cool and wet throughout the Columbia River Basin, with maximum of record precipitation amounts being recorded at some stations. However, in September a very stable upper air wave and an almost stationary, blocking high pressure ridge moved over the Basin. This meteorological situation spelled the onset of one of the driest fall and winter seasons on record. Precipitation was very light in November, December, and January continuing the dry trend established in September and October. Several stations recorded all-time low precipitation amounts for these three months. Most storms moving in from the Gulf of Alaska were diverted abnormally far north for this time of year, resulting in an extremely deficient snowpack over most of the Columbia River Basin. Several of the Southern Idaho tributaries to the Snake River had virtually no snow at the measurement sites.

In mid-February the upper air wave pattern finally began to show signs of becoming unstable and precipitation and snow accumulation during the last five days of February were reminiscent of a normal winter weather sequence. Precipitation totals for March reflected this changed weather situation with amounts near normal to somewhat above normal with the exception of the southern portions of Idaho and Oregon. Snow conditions were somewhat improved after March, but even with this increase, total seasonal accumulations remained well below normal over the entire basin.

The geographical distribution of the accumulated October through April precipitation for the basin, expressed as a percentage of the 1958-1972 average, is shown on Chart 1. This chart points out the severity of the moisture deficiency over the Columbia Basin. No basins show greater than 80 percent of normal precipitation for the period. Areas with greater than 50 percent are northwest Washington, the western portion of the Columbia River drainage area in British Columbia, the Clearwater area and parts of western Montana, and the upper reaches of the Snake River drainage. Areas with less than 25 percent include a large portion of eastern Oregon, central Washington, and southwestern Idaho. Chart 2 depicts the sequence of precipitation and temperatures that occurred throughout the winter, as measured by index stations in the basin.

By 1 April 1977 basin-wide snow accumulation was only 50 percent of normal, with the best conditions on the upper mainstem Columbia snowpack at two-thirds of normal. Snowpack on several central Idaho watersheds was as little as 15 to 20 percent of average. Above normal temperatures melted much of the snowpack in April; and, consequently, much of the area which is normally snow covered on 1 May was completely void of snow, or the snow accumulation was far below average. The May 1 snowpack was only 36 percent of average, the lowest figure recorded since snowpack measurements began nearly 60 years ago. Below normal temperatures and above normal precipitation during the month of May resulted in some minor amounts of snow accumulation at higher elevations, but this did little to alleviate the shortages in snow water content over the basin. The pattern of temperature and precipitation throughout the April-August season is shown on Charts 3 and 4. Chart 3 applies to the Columbia River Basin above The Dalles, Oregon; and Chart 4 applies to the upper Columbia and Kootenay River Basins in Canada. Since the major portion of the runoff which occurs during this season is produced by snowmelt, the temperatures shown are of special significance to system reservoir regulation in that they largely influence the pattern of streamflow.

B. STREAMFLOW

River flows were considerably above normal in August 1976, as a result of record precipitation amounts in several areas within the Columbia Basin. However, record setting dry weather throughout the basin caused river flows to drop to below normal magnitudes throughout the remainder of the fall period. Deficient streamflow continued throughout the winter in most areas, with the exception of the Columbia River drainage area in British Columbia, where streamflows were near normal. Record low flows occurred in many streams during this period. By 1 April, the total unregulated runoff since 1 October was 84 percent of the 1958-72 average for the Columbia River at Birchbank, 76 percent of average at Grand Coulee, 68 percent for the Snake River at Lower Granite Dam, and 62 percent for the Columbia River at The Dalles. In the 49-year period of 1929-77, the 1977 October to March runoff at The Dalles ranks 46th.

Streamflow during the spring-summer snowmelt period was considerably below normal, and in many locations unregulated flows reached record low levels. The January through July 1977 volume runoff of the Columbia River measured at The Dalles, Oregon, was 54.0 million acre-feet. The previous low flow for the January through July period occurred in 1944 when 60.6 million acre-feet was recorded. The mean monthly adjusted streamflow for June, generally the month with the maximum runoff, was 247,600 cfs for the Columbia River at The Dalles, or 45 percent of the 15-year (1958-72) adjusted average and 53 percent of the 40-year (1929-68) modified average. Regulation by upstream reservoirs resulted in an actual recorded average June flow at The Dalles of only 123,600 cfs. The effects of low runoff and reservoir regulation combined to produce the lowest maximum observed mean daily Columbia River flow ever recorded during the spring at The Dalles, 184,300 cfs on 27 May. The maximum would have been lower if the upstream reservoirs had not been operated to create a period of high flow for the U.S. "Fish Flow 1977" operation. Maximum observed mean daily inflow for Mica was 77,800 cfs on 8 June; for Arrow 111,000 cfs on 8 June; for Duncan 18,800 cfs on 8 June; and for Libby 41,100 cfs on 9 June. The natural streamflow patterns for the year are shown on the inflow hydrographs for the Treaty reservoirs, Charts 5, 6, 7, and 8. Observed and computed unregulated hydrographs for Kootenay Lake, Columbia River at Birchbank, Grand Coulee Dam, and The Dalles are shown on Charts 9, 10, 11, and 12, respectively.

C. SEASONAL RUNOFF VOLUMES

The volume and distribution of runoff during the snowmelt season is of great importance because the reservoir regulation plans are determined in part by the expected runoff volume. Runoff volume forecasts, based on precipitation and snowpack data, were prepared for a large number of locations in the Columbia River Basin and updated each month as the season advanced. Table 1 lists the seasonal volume inflow forecasts for Mica, Arrow, Duncan, and Libby projects and the unregulated runoff of the Columbia River at The Dalles. The forecasts for Mica, Arrow, and Duncan inflow were prepared by B.C. Hydro and Power Authority; and those for the Lower Columbia River and Libby inflow were prepared by the United States Columbia River Forecasting Service. Also shown on Table 1 are the actual volumes for these five locations. Observed April-August runoff volumes, adjusted for upstream storage effects, are listed for eight locations in the following tabulation:

Streamflow and Location	Thousands of Acre-feet	Percent of 1958-72 Average
Libby Reservoir Inflow	3,547	50
Duncan Reservoir Inflow	1,652	76
Mica Reservoir Inflow	9,609	79
Arrow Reservoir Inflow	19,541	81
Columbia River at Birchbank	28,850	67
Grand Coulee (FDR) Reservoir Inflow	37,595	58
Snake River at Lower Granite Dam	9,501	40
Columbia River at The Dalles	49,427	50

III RESERVOIR OPERATION

A. McNAUGHTON RESERVOIR

Storage Evacuation Period. As indicated on Chart 5, McNaughton reservoir was filled to elevation 2473.2 feet on 31 July 1976 and continued to fill to 2474.6 feet on 15 August 1976. An operating margin of 0.5 feet below normal full pool elevation of 2475.0 feet was maintained until early October to reduce the chances of having to release high discharges which might damage the cofferdams protecting the tailrace tunnels. During this period, discharges were made through both the spillway and the outlet works. The high discharges were periodically curtailed for short durations to reduce the extreme spray which interfered with access to the powerhouse and the construction activities underway. During October 1976, McNaughton reservoir was drafted to elevation 2471.5 feet for flood control. For a period of 10 days beginning 15 October 1976, the discharge was reduced to minimum during daylight hours to allow dredging of the sand bars which had formed in the tailrace area due to the spillway operation in June and July. McNaughton reservoir was drafted through November and December to meet downstream power requirements, with discharges ranging from 10,000 cfs to 26,000 cfs. Units #2 and #1 at the Mica powerplant were commissioned on 15 December and 19 December 1976, respectively. The project then operated without spill, discharging approximately 20,000 cfs through the turbines from January through March 1977, except for periods of unit inspection and maintenance. On 30 March 1977, unit #3 went into commercial operation and the plant total discharge was increased to 30,000 cfs. On 30 April and 1 May, Mica plant discharges were reduced to minimum to facilitate removal of the cofferdam protecting the tailrace tunnel #2. Plant discharge resumed at 20,000 cfs afterwards. The McNaughton reservoir was at its lowest elevation of 2414.6 feet on 29 April.

Refill Period. Snowmelt runoff began towards the end of April, and McNaughton reservoir began filling in May. From May through August, plant discharges ranged from 17,000 cfs to 26,000 cfs. Discharges were above the filling requirements to meet the Proportional Rule Curve and to restore the Emergency Draft to Arrow reservoir and Duncan reservoir (see Emergency Draft, Arrangement, page 11). The McNaughton reservoir was filled to 2446.6 feet on 31 July and to a maximum of 2455.3 feet on 25 August.

B. ARROW RESERVOIR

Storage Evacuation Period. As indicated on Chart 6, Arrow reservoir filled to elevation 1445.9 feet at Fauquier on 13 July 1976. The 2-foot storage space above full pool elevation 1444.0 feet was used by BPA to store spillable surplus water. Because of the high streamflows, the reservoir elevation was held relatively constant through August, September and early October 1976. Beginning 16 October 1976, the Arrow reservoir began to draft to meet downstream power requirements and by 30 November 1976, it was 5 feet below the Critical Rule Curve. Under the Emergency Draft Arrangement, Arrow reservoir continued to be drafted below the Critical Rule Curve to deliver emergency energy, and reached elevation 1392.0 feet on 15 February. Reservoir elevation was maintained near 1392 feet through and the end of March. On 12 and 13 April, discharge was reduced to a minimum to facilitate the installation of a sewage outfall pipeline downstream of Arrow at Castlegar. During late April and early May, water was stored in the reservoir for subsequent use in the U.S. "Fish Flow 1977" operation between 9 May and 20 June.

Refill Period. Arrow reservoir began to fill in early June and its elevation peaked at 1410.9 feet on 27 June, which is approximately 33 feet below normal full pool elevation of 1444.0 feet. The level began to drop slowly thereafter and was at elevation 1405.4 feet on 31 July and 1401.2 feet on 31 August respectively. Storage was drafted to maintain correct proportionality between the Canadian storage and the U.S. storage, taking into consideration the emergency draft for the Canadian storage system and the "Fish Flow 1977" requirements for the U.S. storage system. In July, BPA and B.C. Hydro reached agreement on an arrangement whereby B.C. Hydro could deliver energy to BPA in lieu of storage draft from Arrow reservoir. This amounted to storing B.C. Hydro's energy in Arrow reservoir. As of 31 August, the amount of B.C. Hydro energy stored in Arrow as 456.4 million killowatt hours the water equivalent of which is 315,500 second-foot-days (sfd).

C. DUNCAN RESERVOIR

Storage Evacuating Period. As indicated on Chart 7, Duncan reservoir reached normal full pool elevation of 1892.0 feet on 24 July 1976 and was maintained near full pool until 2 October 1976, when discharge was increased to 10,000 cfs to maintain the level of Kootenay Lake. The reservoir continued to draft with periods of discharge up to 10,000 cfs. During December 1976 and January 1977, the outflow was reduced to 2,000 cfs to decrease the rate of draft. During February and March, outflow was increased to meet Emergency Draft requirements. On 22 March, Duncan reservoir reached its lowest level, elevation 1794.3 feet.

Refill Period. On 30 March, the project discharge was reduced to a minimum of 100 cfs to facilitate trapping of adult migratory fish downstream of the project. The discharge continued at 100 cfs after the fish trapping was completed on 29 April and until the reservoir reached its full pool elevation of 1892.0 feet on 14 August.

D. LIBBY RESERVOIR

Evacuation Period. As shown on Chart 8. Lake Koocanusa reached normal full pool, elevation 2459.0 feet, on 29 July 1976 and remained near this level until late September. Significant reservoir drafting began near the first of October with the average project outflow through December being about 14,000 cfs. On 29 November about 20,000 cfs was spilled for 12 hours to flush debris from the stilling basin prior to an underwater inspection and damage survey. The total project outflow during this period was 40,000 cfs. Results of the survey indicated serious erosion of the concrete stilling basin. Reservoir storage draft was continued through November and December, to meet the 31 December Upper Rule Curve requirement of elevation 2,410 feet. After 1 January, when runoff forecasts indicated operation below the Variable Refill Curve, operation was guided by proportional draft criteria. Reservoir draft continued throughout the winter, and by mid-March, a total of 85 ft. of storage had been released. Libby outflows were generally lower than powerhouse capacity during the rest of the evacuation period as it became necessary to reduce the inflow into Kootenay Lake in order to maintain the lake below the International Joint Commission Rule Curve, while minimizing spill at the Kootenay River power plants. The lowest level reached prior to refill was elevation 23~~4~~58.5 feet on 26 April.

Refill Period. Libby inflow increased during the last week in Arpil, marking the beginning of a record low spring runoff. On May 7 the outflow was reduced to essentially minimum level and this was held through most of May and June. The low outflows helped offset the excess power generation occurring in the system resulting from the "Fish Flow 1977" operation on the lower and mid-Columbia River. On 28 June the outflow was increased to meet downstream power requirements, and, on 6 July Lake Koocanusa filled to its maximum level for the year, elevation 2415 feet. This is 44 feet below the normal full pool level of the lake.

E. KOOTENAY LAKE

B.C. Hydro completed the installation of Unit #4 at its Kootenay Canal plant on the Kootenay River on 7 October 1976. The plant has four 132 Mw generating units, capable of discharging a total of 28,000 cfs.

The Kootenay Lake regulation, shown on Chart 9, was in compliance with the IJC Order. During the summer of 1976, Kootenay Lake remained on free flow until early September. On 15 September 1976, Kootenay Lake was 0.3 feet below its normal maximum level, elevation 1745.3 feet. During the period October through December 1976, Kootenay Lake discharge ranged between 18,000 cfs and 25,000 cfs, providing energy and capacity for B.C. Hydro's Integrated System. Kootenay Lake began to draft in January 1977, and reached its minimum level, elevation 1739.3 feet by 31 March. On 12 May, the lake reached a maximum elevation of 1743.0 feet through normal operation. On 13 June, it was confirmed that the peak flow for the Kootenay River had passed, and the lake elevation was slowly raised to and maintained near 1743.3 feet as observed at Nelson.

IV. DOWNSTREAM EFFECTS OF STORAGE OPERATION

A. POWER

General. During the period covered by this report, the Treaty storage was operated in accordance with the 1976-77 Detailed Operating Plan designed to achieve optimum power generation in Canada and in the United States of America in accordance with paragraph 7, Annex A, of the Treaty. In 1964 the Canadian Entitlement to downstream power benefits for the 1976-77 Operating Year was purchased by Columbia Storage Power Exchange (CSPE) and exchanged with BPA for specified amounts of power and energy. Deliveries of power and energy specified under the Canadian Entitlement Exchange Agreements and attributable to Arrow, Duncan, and Mica under the provisions of these agreements were made during the 1976-77 Operating Year. In a report dated 6 November 1972, "Downstream Power Benefit Computations for 1977-78 Operating Year", the Entities agreed that the United States Entity is entitled to receive during the period 1 April 1977 through 31 March 1978, from B.C. Hydro and Power Authority 1.5 megawatts of capacity and 5.5 average megawatts of energy in accordance with Sections 7 and 10 of the Canadian Entitlement Purchase Agreement, dated 13 August 1964. On 1 April 1977, BPA began scheduling this capacity and energy from B.C. Hydro and Power Authority.

The generation at downstream projects in the United States, delivered under the Canadian Entitlement Exchange Agreement was 719 average megawatts at rates up to 1373 megawatts from 1 August 1976 through 31 March 1977 and 689 average megawatts at rates up to 1362 megawatts, from 1 April 1977 through 31 July 1977. During the period 1 April 1976 through 31 March 1977, the CSPE participants assigned 159 average megawatts at rates up to 300 megawatts to Pacific Southwest utilities.

Beginning 1 April 1977 the assignment was 154 average megawatts at rates up to 300 megawatts. CSPE power not assigned to Pacific Southwest utilities was used in Pacific Northwest loads.

Review of 1976-77 Operations. The operating year began with high streamflow conditions throughout the Columbia River Basin. Surplus energy, not usable in the Pacific Northwest nor storable for future use, loaded the Pacific Northwest-Pacific Southwest intertie to its capacity. Surplus energy unusable in the Pacific Northwest had prevailed since December 1975. All storage reservoirs had been filled by 31 July 1976. August 1976 was the wettest on record at many weather stations across the Columbia Basin and natural streamflows were the highest in 49 years at The Dalles, Grand Coulee, and Mica. The record high streamflows held reservoirs full and provided generation for all markets until 13 September 1976. Storage draft was then required for Northwest load, and deliveries of surplus hydro energy to the Southwest were discontinued. BPA energy sales to Southwest utilities from 1 July 1976 to 13 September 1976, totaled 5.1 billion kilowatthours. During the period July through December 1976, non-Federal utilities in the Pacific Northwest sold about 4.2 billion kilowatthours of energy to Southwest utilities.

BPA discontinued direct deliveries of nonfirm energy to its industrial customers and secondary energy sales to private utilities on 1 November 1976. Secondary energy sales to public agencies were discontinued on 1 December. The industries continued to serve a decreasing amount of their nonfirm loads with energy from numerous sources. These included a special purchase of firm energy from BPA, advance energy from the provisional draft of U.S. reservoirs and from emergency draft of Columbia River Treaty reservoirs, purchase of a portion of the Centralia steamplant generation, and purchases of energy from non-Federal utilities and agencies in the Pacific Northwest and British Columbia. Between November 1976 and early July 1977, industries reduced their loads normally served with nonfirm power by about 68 percent. Delivery of advance energy results in an obligation, on the part of the industries, to return the energy plus losses if it is required later to serve other firm loads. Return would be through purchase of energy from other sources or curtailment of their own firm energy purchases from BPA. The utility load normally served with secondary energy purchases from the Federal System was carried with their lowest cost thermal generation and purchases from British Columbia.

The combination of heavier demands on reservoir storage to serve power requirements and the lack of snowmelt runoff to refill reservoirs resulted in unseasonably low storage reservoir levels throughout the region. The reservoir storage deficiency on 31 July 1977, the time when reservoirs normally are full, was 12.7 million acre-feet, or 14.1 billion kilowatthours of energy. This deficiency is about 30 percent of the total storage energy that can be generated by drafting reservoirs from full content to empty. About 1.0 million acre-feet of the reservoir deficiency in United States reservoirs was attributed to a program for release of water to aid the downstream migration of anadromous smolts ("Fish Flow 1977") during the period 9 May through 17 June.

This loss in reservoir storage included actual water spilled and overgeneration that was stored with Pacific Southwest utilities. Energy was also stored with B.C. Hydro during the special fish operation but all the energy was returned by 31 July 1977.

The impact of the drought on power resources was reduced by loads underrunning estimates. BPA firm energy loads underran estimates 5 to 7 percent each month during the operating year and the total Northwest loads underran 2 to 8 percent. Loads were down due to the generally mild weather, depressed economic conditions, and conservation efforts by electricity users. On 14 February 1977, BPA joined with other utilities in the area and concerned officials in a public request that all consumers effect 10 percent voluntary curtailment in their use of electricity. Load data collected subsequent to that request indicated significant reduction had been attained in spite of the extremely dry conditions which resulted in power and water demands for irrigation being substantially greater than anticipated.

Four generating units were added to the Federal Columbia River Power System during the August 1976 - July 1977 period. The third large unit at Grand Coulee, G-21, a 600-megawatt unit, was declared available for commercial operation 4 December 1976, and the 95-megawatt units 17 and 18 at Chief Joseph, were placed in commercial operation on 17 June and 26 July 1977, respectively. Also, initial generation began at the Corps of Engineers' Lost Creek project on the Rogue River on 6 July 1977.

<u>"Fish Flow 1977" Operation</u>. Forecasts of extreme low runoff in the early months of 1977 prompted concern by United States fisheries agencies for the survival of fingerling salmon migrating downstream along the mid and lower reaches of the Columbia River. This led to the development of a plan known as "Fish Flow 1977", to create a period of high flow to increase velocities, in the reservoirs and produce periods of spill to enable fingerlings to by-pass turbines. The plan was extensively coordinated among water management and fishery agencies through the Committee on Fisheries Operation, a committee under the auspices of the Columbia River Water Management Group and, it received wide spread publicity and attention by high level state and federal officials. The operation took place between 9 May and 17 June in three phases, each requiring specified flows and spill at specific locations in the river. As a result of the overgeneration and water spilled to produce the required flows, energy equal to a total storage of 1.4 million acre-feet was used. Much of this energy was not lost but stored outside the area, and if all this energy were returned the net loss would be reduced

to 0.23 million acre-feet. From the standpoint of the fishery survival, the operation was considered highly successful.

B. SPECIAL OPERATING ARRANGEMENTS

Storage in Arrow Lakes Above Elevation 1444.0 feet. During the spring of 1976 British Columbia Hydro and Power Authority and Bonneville Power Administration verbally agreed, and established operating procedures, for B.C. Hydro to provide an additional two feet of storage in Arrow Lakes reservoir between elevations 1444.0 and 1446.0 feet. The verbal arrangements were set forth in a letter agreement, Contract No. 14-03-69153, between B.C. Hydro and BPA, effective 16 August 1976. The agreement stipulated that (1) an additional two feet of storage space was provided by B.C. Hydro on or about 1 March 1976, (2) BPA pay B.C. Hydro $1,052,400 on or before 1 September 1976, (3) generation at downstream projects from release of the additional storage will be sold to other users, and (4) the agreement terminate on 31 December 1976. Under this agreement, 132,100 sfd of additional water was stored, carried through the summer months and was released to produce about 253.5 million kilowatthours of energy at downstream projects in the United States. The Entities agreed that operations adopted under the agreement were not in conflict with the Columbia River Treaty operation and the Canadian Entitlement Purchase Agreement. The Operating Committee was instructed to insure that any filling or drafting of the additional Arrow storage not conflict with implementation of the Treaty operating plans.

Emergency Draft Arrangement. To mitigate an energy shortage in the United States resulting from abnormally low precipitation during fall and winter months, BPA entered into an agreement with B.C. Hydro in February 1977 entitled "Emergency Draft Arrangement." Under the terms of this agreement, 442,400 sfd was drafted from Duncan and Arrow reservoirs from 20 February to 16 April 1977 to generate 600 million kilowatthours at downstream Federal projects. The owners of downstream United States non-Federal projects did not participate in the Emergency Draft Arrangement. Generation from the emergency draft at these projects was retained by the project owners in recognition that streamflow at their projects would be correspondingly less when the emergency draft was recovered. A compensating draft of 442,400 sfd was made at Mica to restore Duncan and Arrow reservoir levels during the period 2 May - 16 June 1977. B.C. Hydro was paid $600,000 for use of the water from the emergency draft operation. B.C. Hydro will be paid an additional $60,000 per month beginning August 1977 as long as the emergency draft remains outstanding plus any head loss at Mica associated with this special operation. The agreement terminates 31 July 1979. At that time Mica must be returned to the same level as would have been maintained in the absence of this agreement and/or B.C. Hydro will be paid for the loss of generation at Mica equivalent to the deficiency.

The Entities have agreed that: "No emergency draft nor reservoir restoration nor any step or operation in connection therewith shall be made or taken except that it be, or be deemed to be, in full compliance with the Columbia River Treaty".

Arrow Storage Agreement. B.C. Hydro and BPA entered into an agreement, Contract No. 14-03-79156, dated 18 July 1977, providing for storage in Arrow Lakes reservoir in excess of that which would otherwise be required under the Detailed Operating Plan. During the period 9 July - 31 August 1977, B.C. Hydro delivered 456,412,000 kilowatthours to BPA in lieu of release from Arrow Lakes, thereby providing for the storage of 315,500 sfd of additional water in Arrow Lakes. The additional water may be released to produce energy at downstream Federal projects during the period 30 September 1977 - 31 March 1978 for (1) return to B.C. Hydro with payment to BPA of 1.5 mills/kwh; or (2) purchase by BPA at a cost not to exceed 25 mills per kwh; or if not released for the above purposes, the additional water will be spilled to the extent that it cannot be retained in Arrow Lakes. The Entities have agreed that the operations under the Arrow Storage Agreement are not in conflict with Treaty operations and the Canadian Entitlement Purchase Agreement. The Operating Committee has been instructed to insure that any filling or drafting of the additional Arrow storage does not conflict with implementation of the Treaty operating plans.

C. FLOOD CONTROL

Flood control was not a controlling factor in the regulation of storage reservoirs during the spring runoff in 1977. Without any regulation by upstream reservoirs, the peak flow of the Columbia River at The Dalles would have been only 276,000 cfs, lower than the bankfull capacity of 450,000 cfs. With reservoirs operating for power production and refill, the observed springtime maximum mean daily flow at The Dalles was only 184,300 cfs. Similarly, low spring peaks occurred on upstream tributaries. Observed and unregulated hydrographs for the 1 July 1976 - 31 July 1977 period at The Dalles are shown on Chart 12. These hydrographs are shown compared with the summary hydrograph of previously observed flows at The Dalles. Chart 13 shows the flows at The Dalles for the spring runoff period in 1977. On this chart, the effects of regulation by Mica, Arrow, Duncan, and Libby projects are separated from those of all other major storage projects in the Columbia River Basin.

V. OPERATING CRITERIA

A. GENERAL

The Columbia River Treaty requires that the reservoirs constructed in Canada be operated pursuant to flood control and hydroelectric operating plans developed thereunder. Annex A of the Treaty stipulates that the United States Entity will submit flood control operating plans and the Canadian Entity will operate in accordance with flood control storage diagrams or any variation which the Entities agree will not be adverse to the desired aim of the flood control plan. Annex A also provided for the development of hydroelectric operating plans five years in advance to furnish the Entities with an Assured Operating Plan for Canadian Storage. In addition, Article XIV.2.k of the Treaty provided that a Detailed Operating Plan may be developed to produce more advantageous results through use of current estimates of loads and resources. The Protocol to the Treaty provided further detail and clarification of the principles and requirements of Annex A. The Principles and Procedures of 25 25 July 1967, together with the Columbia River Treaty Flood Control Operating Plan dated October 1972, both developed by special task forces, establish the general criteria of operations.

The Assured Operating Plan dated January 1972 established Operating Rule Curves for Duncan, Arrow, and Mica for the 1976-77 Operating Year. The Operating Rule Curves provided guidelines for refill levels as well as drawdown levels. They were derived from Critical Rule Curves, Assured Refill Curves, and simulated Variable Refill Curves consistent with flood control requirements, as described in the Principles and Procedures. The Flood Control Storage Reservation Curves were established to conform to the Flood Control Operating Plan.

The Detailed Operating Plan dated September 1976 established data and criteria for determining the Operating Rule Curves for use in actual operations. At the request of the Canadian Entity these criteria included the Critical Rule Curves for Duncan, Arrow, and Mica agreed in the 1976-77 Assured Operating Plan dated January 1972. The Variable Refill Curves and flood control requirements subsequent to 1 January 1977, were determined on the basis of seasonal volume runoff forecasts during actual operation.

B. POWER OPERATION

Prior to the 1976-77 operating year, each Detailed Operating Plan was designed to achieve optimum generation downstream in the United States. However, since generators at Mica were installed during this operating year, the Detailed Operating Plan dated September 1976 was designed to achieve optimum power generation at site in Canada and downstream in Canada and the United States, consistent with project operating limits and flood control requirements.

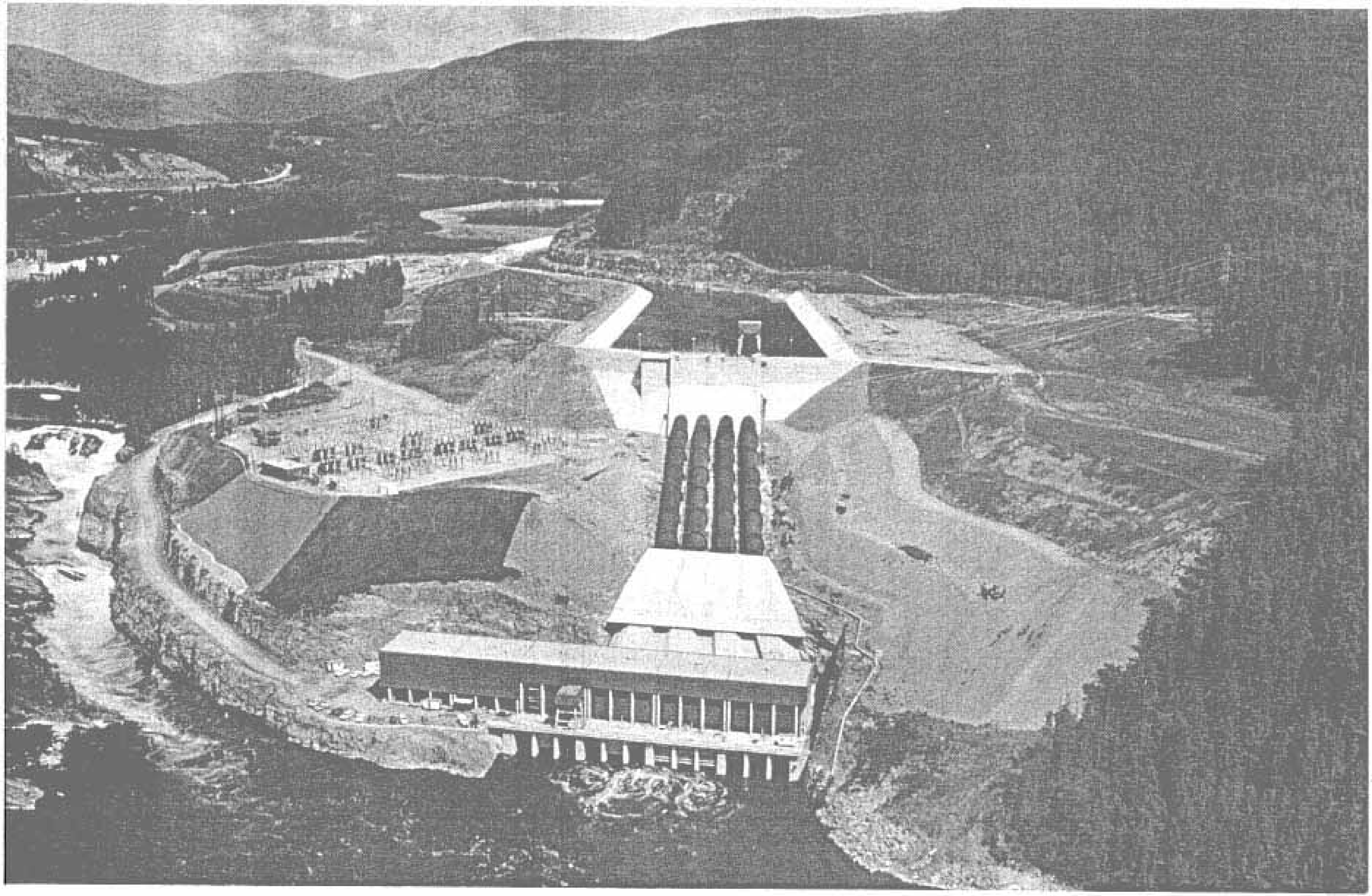
The power facilities in the United States which are downstream from the Treaty storage projects are all operated under the Pacific Northwest Coordination Agreement dated September 1964. Optimum generation in the United States was assured by the adoption, in the Assured and Detailed Operating Plans, of criteria and operating guides designed to coordinate the operation of Treaty projects with the projects operating under the Agreement. Optimum operation of Treaty reservoirs was accomplished, for the actual water condition experienced, by operating with reference to the Critical Rule Curves, Assured Refill Curves, Variable Refill Curves, Flood Control Storage Reservation Curves, and related criteria determined in accordance with the Detailed Operating Plan.

C. FLOOD CONTROL OPERATION

The Flood Control Operating Plan was designed to minimize flood damage both in Canada and in the United States. The flood control operation during the drawdown period consisted of evacuation and holding available storage space, consistent with refill criteria, sufficient to control and maximum flood that may occur under forecast conditions. Runoff volume forecasts determined the volume of storage space required. Because of the extreme low runoff during the spring of 1977, no flood control operation was required.

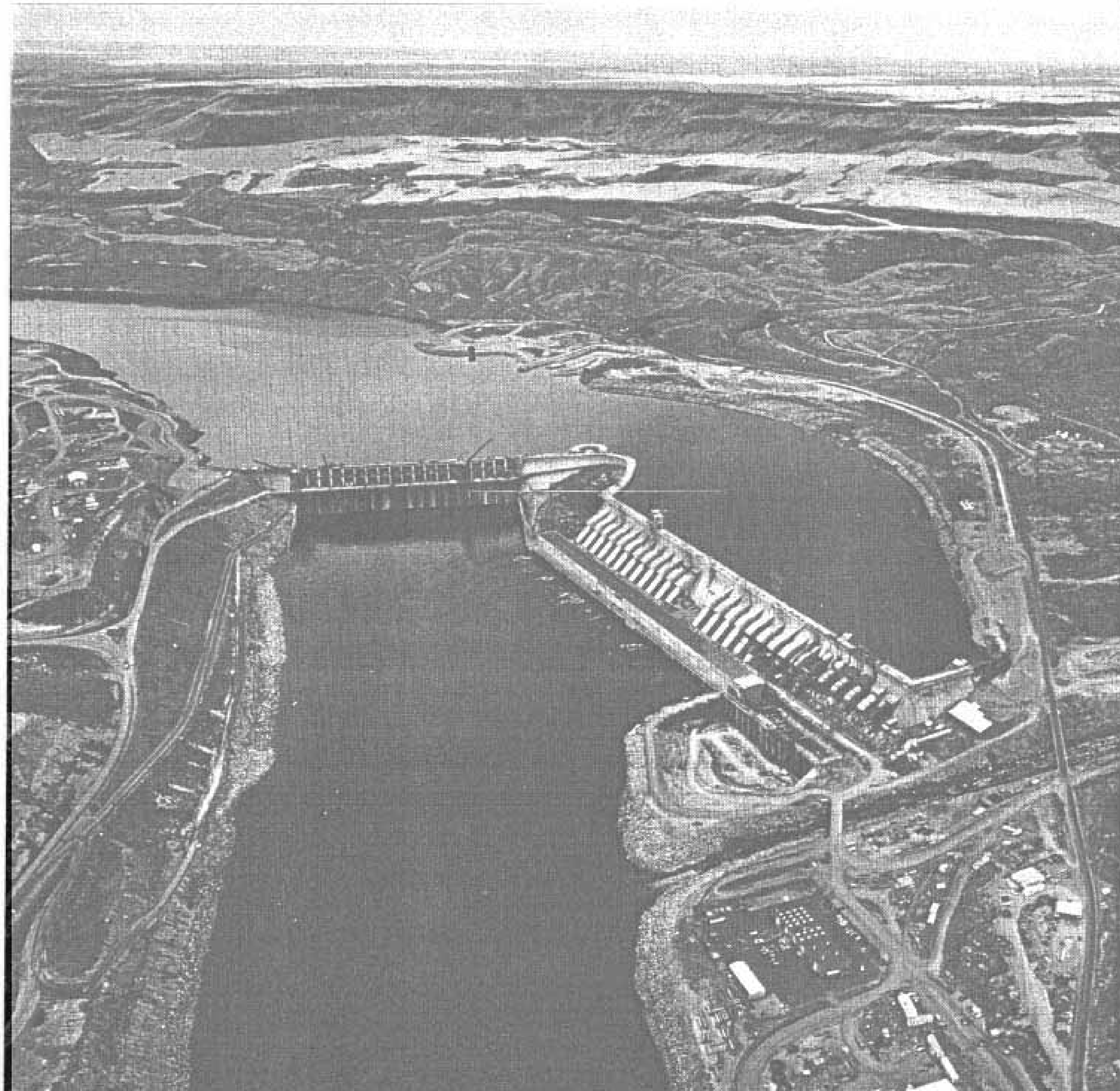
An aerial view of Nakusp, British Columbia, on the banks of the Arrow Lakes. The picture shows extensive areas of sand left exposed with a lake elevation of 1399.6 feet recorded on 12 September 1977.

B.C. Hydro and Power Authority Photograph



Construction of B.C. Hydro's Kootenay Canal hydro-electric development on the south side of the Kootenay River, about mid-way between Nelson and Castlegar, commenced in the fall of 1971. It was declared operational in October 1975. With four generating units in operation the plant has a total capacity of 529,200 kilowatts.

B.C. Hydro and Power Authority Photograph



A July 1977 view of Chief Joseph project showing construction of the spillway modification and eleven additional generating units. The modification will increase the normal maximum pool elevation and add 1,045,000 kilowatts to the name plate rating of the project.

U.S. Army Corps of Engineers Photograph

TABLE 1

UNREGULATED RUNOFF VOLUME FORECASTS
MILLIONS OF ACRE-FEET
1977

	DUNCAN	ARROW	MICA	LIBBY	UNREGULATED RUNOFF COLUMBIA RIVER AT THE DALLES, OREGON
Forecast Date - 1st of	Most Probable 1 Apr - 31 Aug	Most Probable 1 Apr - 31 Aug	Most Probable 1 Apr - 31 Aug	Most Probable 1 Apr - 31 Aug	Most Probable 1 Jan - 31 Jul
January	1.87	20.65	11.04	5.22	75.70
February	1.74	18.57	10.21	4.70	62.20
March	1.77	18.76	10.23	3.71	55.90
April	1.74	18.93	10.29	3.94	58.10
May	1.72	18.87	10.02	3.47	53.80
June	1.78	19.29	10.25	3.59	57.40
Actual	1.65	19.54	9.61	3.55	54.00

NOTE: These data are as used in actual operations. Subsequent revisions have been made in some cases.

McNAUGHTON RESERVOIR COMPUTATION FORM
95 PERCENT CONFIDENCE FORECAST AND VARIABLE REFILL CURVE
1977

	INITIAL	JAN 1	FEB 1	MAR 1	APR 1	MAY 1	JUN 1
1. PROBABLE FEB 1-JULY 31 INFLOW, KSFD 1/		4603.2	4362.3	4300.4	4299.1	4210.6	4299.1
2. 95% FORECAST ERROR, KSFD		771.5	586.9	525.3	496.3	488.8	477.7
3. 95% CONFIDENCE FEB 1-JULY 31 INFLOW, KSFD 2/		3831.7	3775.5	3775.1	3802.8	3721.8	3821.4
4. OBSERVED FEB 1-DATE INFLOW, KSFD				100.9	195.3	441.9	1139.5
5. 95% CONFIDENCE DATE-JULY 31 INFLOW, KSFD 3/		3831.7	3775.4	3674.2	3607.5	3279.9	2681.9
ASSUMED FEB 1-JULY 31 INFLOW, % VOLUME		100.0					
ASSUMED FEB 1-JULY 31 INFLOW, KSFD 4/		3831.7					
MIN. FEB 1-JULY 31 OUTFLOW, KSFD		1980.2					
MIN. JAN 31 RESERVOIR CONTENT, KSFD 5/		1677.7					
MIN. JAN 31 RESERVOIR ELEVATION, FT. 6/		2437.9					
JAN 31 VARIABLE REFILL CURVE, FT. 7/	2443.6	2437.9					
ASSUMED MAR 1-JULY 31 INFLOW, % VOLUME		97.9	97.9				
ASSUMED MAR 1-JULY 31 INFLOW, KSFD 4/		3751.2	3696.1				
MIN. MAR 1-JULY 31 OUTFLOW, KSFD		1756.2	1756.2				
MIN. FEB 28 RESERVOIR CONTENT, KSFD 5/		1534.2	1589.3				
MIN. FEB 28 RESERVOIR ELEVATION, FT. 6/		2434.8	2436.0				
FEB 28 VARIABLE REFILL CURVE, FT. 7/	2433.2	2433.2	2433.2				
ASSUMED APR 1-JULY 31 INFLOW, % VOLUME		95.6	95.6	97.6			
ASSUMED APR 1-JULY 31 INFLOW, KSFD 4/		3663.1	3609.3	3586.0			
MIN. APR 1-JULY 31 OUTFLOW, KSFD		1508.2	1508.2	1508.2			
MIN. MAR 31 RESERVOIR CONTENT, KSFD 5/		1374.3	1428.1	1451.4			
MIN. MAR 31 RESERVOIR ELEVATION, FT. 6/		2431.4	2332.6	2433.1			
MAR 31 VARIABLE REFILL CURVE, FT. 7/	2425.3	2425.3	2425.3	2425.3			
ASSUMED MAY 1-JULY 31 INFLOW, % VOLUME		91.4	91.4	93.3	95.6		
ASSUMED MAY 1-JULY 31 INFLOW, KSFD 4/		3502.1	3450.7	3428.0	3448.8		
MIN. MAY 1-JULY 31 OUTFLOW, KSFD		1160.2	1160.2	1160.2	1160.2		
MIN. APR 30 RESERVOIR CONTENT, KSFD 5/		1187.3	1238.7	1261.4	1240.6		
MIN. APR 30 RESERVOIR ELEVATION, FT. 6/		2427.3	2428.5	2429.0	2428.5		
APR 30 VARIABLE REFILL CURVE, FT. 7/	2417.2	2417.2	2417.2	2417.2	2417.2		
ASSUMED JUN 1-JULY 31 INFLOW, % VOLUME		74.2	74.2	75.8	77.6	81.2	
ASSUMED JUN 1-JULY 31 INFLOW, KSFD 4/		2843.1	2801.4	2785.0	2799.5	2663.3	
MIN. JUN 1-JULY 31 OUTFLOW, KSFD		800.6	800.6	800.6	800.6	800.6	
MIN. MAY 31 RESERVOIR CONTENT, KSFD 5/		1486.7	1528.4	1544.8	1530.3	1666.5	
MIN. MAY 31 RESERVOIR ELEVATION, FT. 6/		2433.8	2434.7	2435.0	2434.7	2437.6	
MAY 31 VARIABLE REFILL CURVE, FT. 7/	2425.7	2425.7	2425.7	2425.7	2425.7	2425.7	
ASSUMED JUL 1-JULY 31 INFLOW, % VOLUME		36.0	36.0	36.8	37.6	39.4	48.5
ASSUMED JUL 1-JULY 31 INFLOW, KSFD 4/		1379.4	1359.1	1352.1	1356.4	1292.3	1300.7
MIN. JUL 1-JULY 31 OUTFLOW, KSFD		452.6	452.6	452.6	452.6	452.6	452.6
MIN. JUN 30 RESERVOIR CONTENT, KSFD 5/		2602.4	2622.7	2629.7	2625.4	2689.5	2681.1
MIN. JUN 30 RESERVOIR ELEVATION, FT. 6/		2456.7	2457.1	2457.3	2457.2	2458.4	2458.3
JUN 30 VARIABLE REFILL CURVE, FT. 7/	2453.7	2453.7	2453.7	2453.7	2453.7	2453.7	2453.7
JULY 31 VARIABLE REFILL CURVE, FT.	2474.5	2474.5	2474.5	2474.5	2474.5	2474.5	2474.5
NOTE - ACCUMULATED DEAD STORAGE IS		6565.1	6565.1	6565.1	6565.1	6565.1	6565.1

1/ DEVELOPED BY CANADIAN ENTITY
2/ LINE 1-LINE 2
3/ LINE 3-LINE 4
4/ PRECEDING LINE X LINE 5
5/ FULL CONTENT (3529.2) PLUS PRECEDING LINES LESS LINE PRECEDING THAT (USABLE STORAGE).
6/ FROM RESERVOIR ELEVATION - STORAGE CONTENT TABLE DATED MARCH 25, 1974 (FOOTNOTE 5 PLUS ASCUMULATED DEAD STORAGE)
7/ LOWER OF ELEVATION ON PRECEDING LINE OR ELEVATION DETERMINED BY ADDING DEAD STORAGE TO INITIAL CONTENTS.

ARROW LAKES COMPUTATION FORM
95 PERCENT CONFIDENCE FORECAST AND VARIABLE REFILL CURVE
1977

	INITIAL	JAN 1	FEB 1	MAR 1	APR 1	MAY 1	JUN 1
1. PROBABLE FEB 1 - JULY 31 INFLOW, KSFD 1/		9061.9	8396.8	8318.2	8438.7	8465.9	8672.5
2. 95% FORECAST ERROR, KSFD		1797.8	1374.4	1279.6	1107.3	1027.8	993.5
3. 95% CONFIDENCE FEB 1 - JULY 31 INFLOW, KSFD 2/		7264.1	7022.4	7038.6	7331.4	7438.1	7679.0
4. OBSERVED FEB 1 - DATA INFLOW, KSFD				293.0	577.0	1348.1	3148.2
5. 95% CONFIDENCE DATE - JULY 31 INFLOW, KSFD 3/		7264.1	7022.4	6745.6	6754.4	6090.0	4530.8
ASSUMED FEB 1 - JULY 31 INFLOW, % VOLUME		100.0					
ASSUMED FEB 1 - JULY 31 INFLOW, KSFD 4/		7264.1					
MIN. FEB 1 - JULY 31 OUTFLOW, KSFD		2957.0					
MICA REFILL REQUIREMENTS, KSFD 5/		1851.5					
MIN. JAN 31 CONTENTS, KSFD 6/		1124.0					
MIN. JAN 31 ELEVATION, FT. 7/		1402.2					
JAN 31 VARIABLE REFILL CURVE, FT. 8/	1404.5	1402.2					
ASSUMED MAR 1 - JULY 31 INFLOW, % VOLUME		97.4	97.4				
ASSUMED MAR 1 - JULY 31 INFLOW, KSFD 4/		7075.2	6839.8				
MIN. MAR 1 - JULY 31 OUTFLOW, KSFD		2817.0	2817.0				
MICA REFILL REQUIREMENTS, KSFD 5/		2070.8	2070.8				
MIN. FEB 28 CONTENTS, KSFD 6/		1392.2	1627.6				
MIN. FEB 28 ELEVATION, FT. 7/		1407.3	1411.6				
FEB 28 VARIABLE REFILL CURVE, FT. 8/	1399.0	1399.0	1399.0				
ASSUMED APR 1 - JULY 31 INFLOW, % VOLUME		94.3	94.3	96.8			
ASSUMED APR 1 - JULY 31 INFLOW, KSFD 4/		6850.0	6622.1	6529.8			
MIN. APR 1 - JULY 31 OUTFLOW, KSFD		2662.0	2662.0	2662.0			
MICA REFILL REQUIREMENTS, KSFD 5/		2434.5	2434.5	2434.5			
MIN. MAR 31 CONTENTS, KSFD 6/		1826.1	2054.0	2146.3			
MIN. MAR 31 ELEVATION, FT. 7/		1415.2	1419.2	1420.8			
MAR 31 VARIABLE REFILL CURVE, FT. 8/	1397.4	1397.4	1397.4	1397.4			
ASSUMED MAY 1 - JULY 31 INFLOW, % VOLUME		87.3	87.3	89.6	92.6		
ASSUMED MAY 1 - JULY 31 INFLOW, KSFD 4/		6341.5	6130.6	6044.1	6254.6		
MIN. MAY 1 - JULY 31 OUTFLOW, KSFD		2137.0	2137.0	2137.0	2137.0		
MICA REFILL REQUIREMENTS, KSFD 5/		2796.6	2796.9	2796.6	2796.0		
MIN. APR 30 CONTENTS, KSFD 6/		2171.6	2382.6	2469.1	2258.6		
MIN. APR 30 ELEVATION, FT. 7/		1421.3	1424.9	1426.3	1422.8		
APR 30 VARIABLE REFILL CURVE, FT. 8/	1384.3	1384.3	1384.3	1384.3	1384.3		
ASSUMED JUN 1 - JULY 31 INFLOW, % VOLUME		63.4	63.4	65.1	67.3	72.6	
ASSUMED JUN 1 - JULY 31 INFLOW, KSFD 4/		4605.4	4452.2	4391.4	4545.7	4421.4	
MIN. JUN 1 - JULY 31 OUTFLOW, KSFD		1594.5	1594.5	1594.5	1594.5	1594.5	
MICA REFILL REQUIREMENTS, KSFD 5/		2416.3	2416.3	2416.3	2416.3	2416.3	
MIN. MAY 31 CONTENTS, KSFD 6/		2985.0	3138.2	3199.0	3044.7	3169.1	
MIN. MAY 31 ELEVATION, FT. 7/		1434.7	1437.2	1438.1	1435.7	1437.6	
MAY 31 VARIABLE REFILL CURVE, FT. 8/	1408.2	1408.2	1408.2	1408.2	1408.2	1408.2	
ASSUMED JUL 1 - JULY 31 INFLOW, % VOLUME		26.3	26.3	27.0	27.9	30.1	41.4
ASSUMED JUL 1 - JULY 31 INFLOW, KSFD 4/		1910.5	1846.9	1821.3	1884.5	1833.1	1875.7
MIN. JUL 1 - JULY 31 OUTFLOW, KSFD		1069.5	1096.5	1069.5	1069.5	1069.5	1069.5
MICA REFILL REQUIREMENTS, KSFD 5/		1078.5	1078.5	1078.5	1078.5	1078.5	1078.5
MIN. JUN 30 CONTENTS, KSFD 6/		3817.2	3880.7	3906.3	3843.2	3894.5	3851.9
MIN. JUN 30 ELEVATION, FT. 7/		1447.6	1448.6	1448.9	1448.0	1448.8	1448.1
JUN 30 VARIABLE REFILL CURVE, FT. 8/	1434.9	1434.9	1434.9	1434.9	1434.9	1434.9	1434.9
JULY 31 VARIABLE REFILL CURVE, FT.	1444.0	1444.0	1444.0	1444.0	1444.0	1444.0	1444.0

1/ DEVELOPED BY CANADIAN ENTITY
2/ LINE 1 - LINE 2
3/ LINE 3 - LINE 4
4/ PRECEDING LINE X LINE 5
5/ MICA FULL CONTENT VARIABLE REFILL CURVE FROM MICA VRC COMPUTATION FORM
6/ FULL CONTENT (3579.6 KSFD) PLUS TWO PRECEDING LINES LESS LINE PRECEDING THAT
7/ FROM RESERVOIR ELEVATION-STORAGE CONTENT TABLE DATED FEBRUARY 28, 1974
8/ LOWER OF THE ELEVATION ON PRECEDING LINE OR ELEVATION DETERMINED PRIOR TO YEAR (INITIAL)

DUNCAN RESERVOIR COMPUTATION FORM
95 PERCENT CONFIDENCE FORECAST AND VARIABLE REFILL CURVE
1977

	INITIAL	JAN 1	FEB 1	MAR 1	APR 1	MAY 1	JUN 1
1. PROBABLE FEB 1-JULY 31 INFLOW, KSFD 1/		820.2	772.8	769.7	758.5	753.8	777.0
2. 95% FORECAST ERROR, KSFD		156.1	126.9	120.9	116.9	110.5	95.5
3. 95% CONFIDENCE FEB 1-JULY 31 INFLOW, KSFD 2/		664.1	645.9	648.8	641.6	643.3	681.5
4. OBSERVED FEB 1-DATE INFLOW, KSFD				15.5	34.3	94.4	239.4
5. 95% CONFIDENCE DATE-JULY 31 INFLOW, KSFD 3/		664.1	645.9	633.3	607.3	548.9	442.1
ASSUMED FEB 1-JULY 31 INFLOW, % VOLUME		100.0					
ASSUMED FEB 1-JULY 31 INFLOW, KSFD 4/		664.1					
MIN. FEB 1-JULY 31 OUTFLOW, KSFD		213.3					
MIN. JAN 31 RESERVOIR CONTENT, KSFD 5/		255.0					
MIN. JAN 31 RESERVOIR ELEVATION, FT. 6/		1836.8					
JAN 31 VARIABLE REFILL CURVE, FT. 7/	1836.7	1836.7					
ASSUMED MAR 1-JULY 31 INFLOW, % VOLUME		97.9	97.9				
ASSUMED MAR 1-JULY 31 INFLOW, KSFD 4/		650.2	632.4				
MIN. MAR 1-JULY 31 OUTFLOW, KSFD		210.5	210.5				
MIN. FEB 28 RESERVOIR CONTENT, KSFD 5/		266.1	283.9				
MIN. FEB 28 RESERVOIR ELEVATION, FT. 6/		1838.3	1840.7				
FEB 28 VARIABLF REFILL CURVE, FT. 7/	1835.3	1835.3	1835.3				
ASSUMED APR 1-JULY 31 INFLOW, % VOLUME		95.5	95.5	97.5			
ASSUMED APR 1-JULY 31 INFLOW, KSFD 4/		634.3	616.9	617.5			
MIN. APR 1-JULY 31 OUTFLOW, KSFD		207.4	207.4	207.4			
MIN. MAR 31 RESERVOIR CONTENT, KSFD 5/		278.9	296.3	295.7			
MIN. MAR 31 RESERVOIR ELEVATION, FT. 6/		1840.0	1842.4	1842.3			
MAR 31 VARIABLE REFILL CURVE, FT. 7/	1837.2	1837.2	1837.2	1837.2			
ASSUMED MAY 1-JULY 31 INFLOW, % VOLUME		90.4	90.4	92.3	94.7		
ASSUMED MAY 1-JULY 31 INFLOW, KSFD 4/		600.4	583.9	584.5	575.1		
MIN. MAY 1-JULY 31 OUTFLOW, KSFD		156.4	156.4	156.4	156.4		
MIN. APR 30 RESERVOIR CONTENT, KSFD 5/		261.8	278.3	277.7	287.1		
MIN. APR 30 RESERVOIR ELEVATION, FT. 6/		1837.7	1840.0	1839.9	1841.1		
APR 30 VARIABLE REFILL CURVE, FT. 7/	1834.2	1834.2	1834.2	1834.2	1834.2		
ASSUMED JUN 1-JULY 31 INFLOW, % VOLUME		71.4	71.4	72.9	74.8	79.0	
ASSUMED JUN 1-JULY 31 INFLOW, KSFD 4/		474.2	461.2	461.7	454.3	433.6	
MIN. JUN 1-JULY 31 OUTFLOW, KSFD		103.7	103.7	103.7	103.7	103.7	
MIN. MAY 31 RESERVOIR CONTENT, KSFD 5/		335.3	348.3	347.8	355.2	375.9	
MIN. MAY 31 RESERVOIR ELEVATION, FT. 6/		1847.5	1849.2	1849.2	1850.1	1852.8	
MAY 31 VARIABLE REFILL CURVE, FT. 7/	1848.6	1847.5	1848.6	1848.6	1848.6	1848.6	
ASSUMED JULY 1-JULY 31 INFLOW, % VOLUME		32.5	32.5	33.1	34.0	35.9	45.5
ASSUMED JULY 1-JULY 31 INFLOW, KSFD 4/		215.8	209.9	209.6	206.5	197.0	201.1
MIN. JULY 1-JULY 31 OUTFLOW, KSFD		52.7	52.7	52.7	52.7	52.7	52.7
MIN. JUN 30 RESERVOIR CONTENT, KSFD 5/		542.7	548.6	548.9	552.0	561.5	557.4
MIN. JUN 30 RESERVOIR ELEVATION, FT. 6/		1873.2	1873.9	1873.9	1874.3	1875.4	1874.9
JUN 30 VARIABLE REFILL CURVE, FT. 7/	1872.0	1872.0	1872.0	1872.0	1872.0	1872.0	1872.0
JULY 31 VARIABLE REFILL CURVE, FT.	1892.0	1892.0	1892.0	1892.0	1892.0	1892.0	1892.0

1/ DEVELOPED BY CANADIAN ENTITY
2/ LINE 1-LINE 2
3/ LINE 3-LINE 4
4/ PRECEDING LINE X LINE 5
5/ FULL CONTENT (705.8) PLUS PRECEDING LINE LESS LINE PRECEDING THAT
6/ FROM RESERVOIR ELEVATION-STORAGE CONTENT TABLE DATED JUNE 20, 1974
7/ LOWER OF ELEVATION ON PRECEDING LINE OR ELEVATION DETERMINED PRIOR TO YEAR (INITIAL)

LIBBY COMPUTATION FORM

95 PERCENT CONFIDENCE FORECAST AND VARIABLE REFILL CURVE

1977

	INITIAL	JAN. 1	FEB. 1	MAR. 1	APR. 1	MAY 1	JUN. 1
1. 95% CONFIDENCE JAN 1 - JULY 31 INFLOW, KSFD 1/		1693.5	1605.8	1408.7	1360.8	1087.0	700.8
2. OBSERVED JAN 1 - DATE INFLOW, KSFD		0.0	0.0	0.0	0.0	0.0	0.0
3. RESIDUAL 95% DATE - JUL 31 INFLOW, KSFD 2/		1693.5	1605.8	1408.7	1360.8	1087.0	700.8
ASSUMED FEB 1 - JUL 31 INFLOW, % VOLUME		96.94					
ASSUMED FEB 1 - JUL 31 INFLOW, KSFD 3/		1641.7					
MIN. FEB 1 - JUL 31 OUTFLOW, KSFD		689.4					
MIN. JAN 31 RESERVOIR CONTENT, KSFD 4/		1550.7					
MIN. JAN 31 RESERVOIR ELEVATION, FT. 5/		2413.9					
JAN 31 VARIABLE REFILL CURVE, FT. 6/	2403.4	2403.4					
ASSUMED MAR 1 - JUL 31 INFLOW, % VOLUME		94.17	97.14				
ASSUMED MAR 1 - JUL 31 INFLOW, KSFD 3/		1594.8	1559.9				
MIN. MAR 1 - JUL 31 OUTFLOW, KSFD		605.4	605.4				
MIN. FEB 28 RESERVOIR CONTENT, KSFD 4/		1513.6	1548.5				
MIN. FEB 28 RESERVOIR ELEVATION, FT. 5/		2411.9	2413.8				
FEB 28 VARIABLE REFILL CURVE, FT. 6/	2402.0	2402.0	2402.0				
ASSUMED APR 1 - JUL 31 INFLOW, % VOLUME		90.79	93.66	96.42			
ASSUMED APR 1 - JUL 31 INFLOW, KSFD 3/		1537.5	1504.0	1358.22			
MIN. APR 1 - JUL 31 OUTFLOW, KSFD		512.4	512.4	512.4			
MIN. MAR 31 RESERVOIR CONTENT, KSFD 4/		1477.9	1511.4	1657.2			
MIN. MAR 31 RESERVOIR ELEVATION, FT. 5/		2409.9	2411.8	2419.7			
MAR 31 VARIABLE REFILL CURVE, FT. 6/	2400.8	2400.8	2400.8	2400.8			
ASSUMED MAY 1 - JUL 31 INFLOW, % VOLUME		81.71	84.29	86.77	90.00		
ASSUMED MAY 1 - JUL 31 INFLOW, KSFD 3/		1383.8	1353.5	1222.3	1224.7		
MIN. MAY 1 - JUL 31 OUTFLOW, KSFD		386.4	386.4	386.4	386.4		
MIN. APR 30 RESERVOIR CONTENT, KSFD 4/		1505.6	1535.9	1667.1	1664.7		
MIN. APR 30 RESERVOIR ELEVATION, FT. 5/		2411.4	2413.1	2420.4	2420.2		
APR 30 VARIABLE REFILL CURVE, FT. 6/	2399.3	2399.3	2399.3	2399.3	2399.3		
ASSUMED JUN 1 - JUL 31 INFLOW, % VOLUME		52.75	54.42	56.02	58.10	64.56	
ASSUMED JUN 1 - JUL 31 INFLOW, KSFD 3/		893.3	873.9	789.1	790.6	701.8	
MIN. JUN 1 - JUL 31 OUTFLOW, KSFD		256.2	256.2	256.2	256.2	256.2	
MIN. MAY 31 RESERVOIR CONTENT, KSFD 4/		1865.9	1885.3	1970.1	1968.6	2057.4	
MIN. MAY 31 RESERVOIR ELEVATION, FT. 5/		2430.4	2431.3	2435.5	2435.4	2439.3	
MAY 31 VARIABLE REFILL CURVE, FT. 6/	2424.2	2424.2	2424.2	2424.2	2424.2	2424.2	
ASSUMED JUL 1 - JUL 31 INFLOW, % VOLUME		18.97	19.57	20.15	20.90	23.22	35.97
ASSUMED JUL 1 - JUL 31 INFLOW, KSFD 3/		321.3	314.3	283.8	284.4	252.4	252.1
MIN. JUL 1 - JUL 31 OUTFLOW, KSFD		130.2	130.2	130.2	130.2	130.2	130.2
MIN. JUN 30 RESERVOIR CONTENT, KSFD 4/		2311.9	2318.9	2349.4	2348.8	2380.8	2381.1
MIN. JUN 30 RESERVOIR ELEVATION, FT. 5/		2451.4	2451.7	2453.0	2453.0	2454.6	2454.7
JUN 30 VARIABLE REFILL CURVE, FT. 6/	2450.3	2450.3	2450.3	2450.3	2450.3	2450.3	2450.3
JULY 31 VARIABLE REFILL CURVE, FT.		2459.0	2459.0	2459.0	2459.0	2459.0	2459.0

1/ .50417 TIMES SUM OF TWO SUB BASIN 95% INFLOW FORECASTS, (KAF)
2/ LINE 1 MINUS LINE 2
3/ PRECEDING LINE X LINE 3
4/ FULL CONTENT (2487.3 KSFD) PLUS PRECEDING LINE LESS LINE PRECEDING THAT
5/ FROM RESERVOIR ELEVATION-STORAGE CONTENT TABLE DATED MARCH 17, 1972
6/ LOWER OF ELEVATION ON PRECEDING LINE OR ELEVATION DETERMINED PRIOR TO YEAR, BUT NOT LESS THAN THE LOWEST RULE CURVE

COLUMBIA RIVER BASIN
OCTOBER 76 - APRIL 77 PRECIPITATION
PERCENT OF 1958-72 AVERAGE

CHART I
SEASONAL
PRECIPITATION

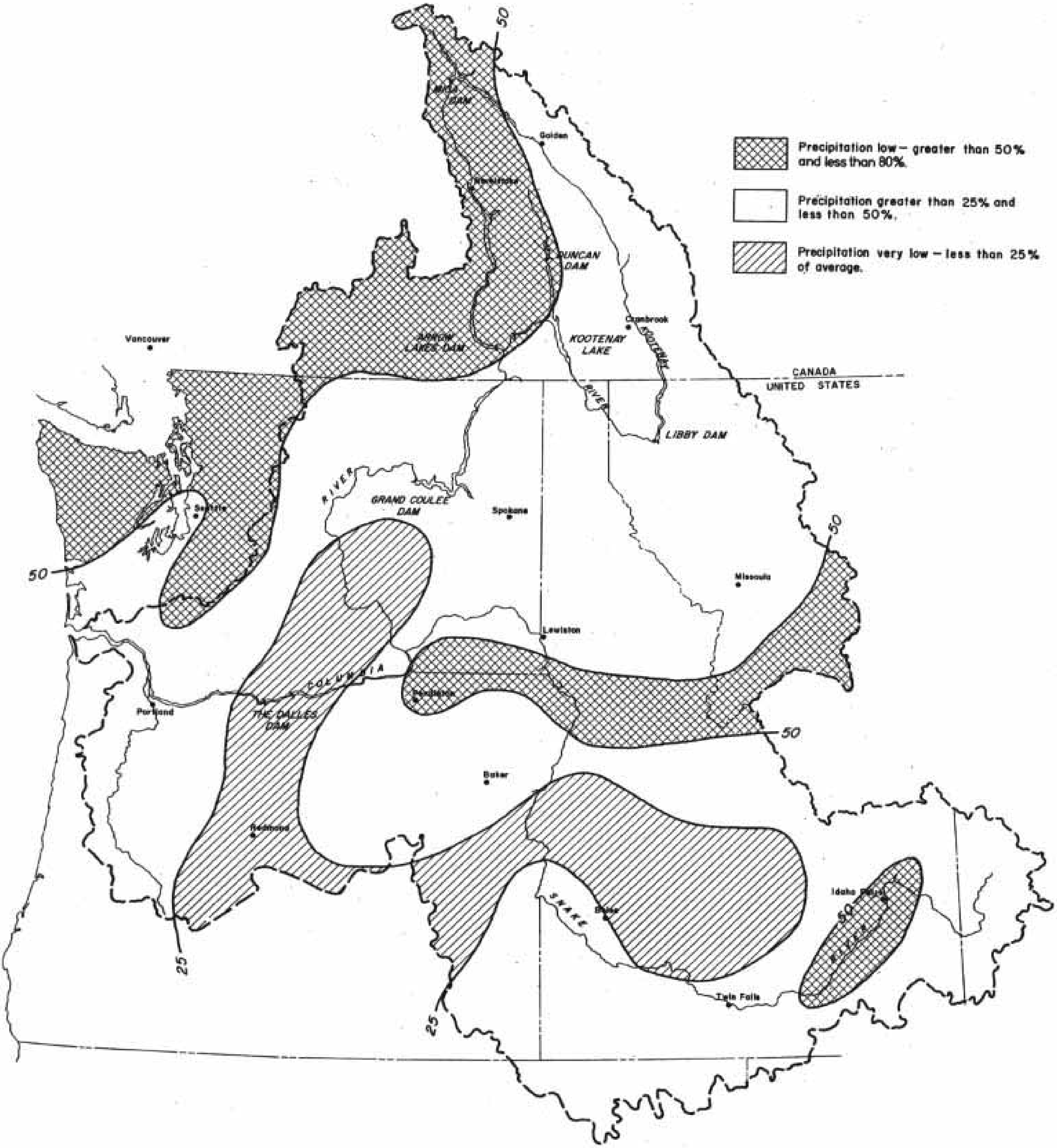
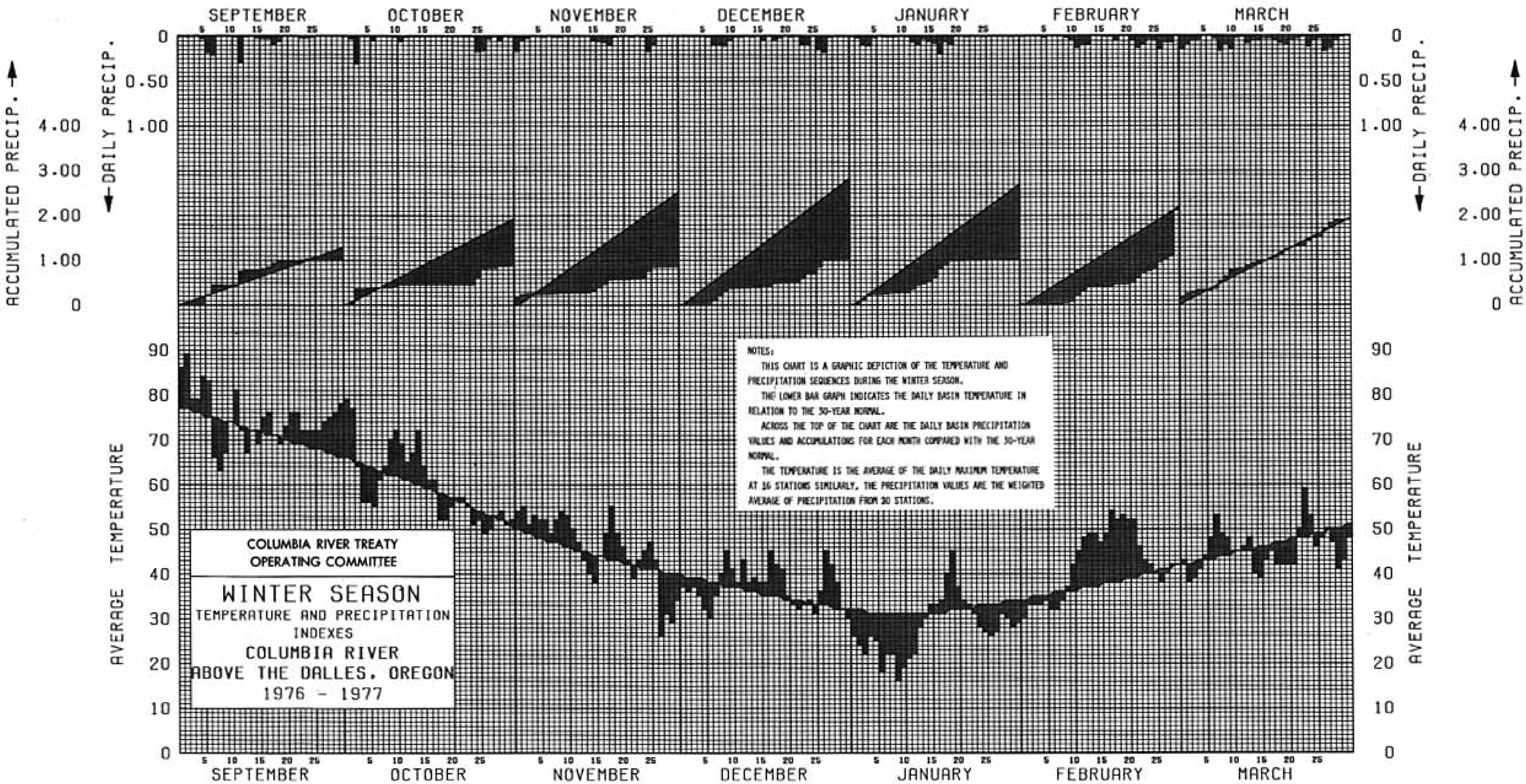


CHART 2



SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
ACCUMULATED PRECIP.
DAILY PRECIP.
AVERAGE TEMPERATURE
0
0.50
1.00
4.00
3.00
2.00
1.00
0
90
80
70
60
50
40
30
20
10
0
5 10 15 20 25
NOTES:
THIS CHART IS A GRAPHIC DEPICTION OF THE TEMPERATURE AND PRECIPITATION SEQUENCES DURING THE WINTER SEASON.
THE LOWER BAR GRAPH INDICATES THE DAILY BASIN TEMPERATURE IN RELATION TO THE 30-YEAR NORMAL.
ACROSS THE TOP OF THE CHART ARE THE DAILY BASIN PRECIPITATION VALUES AND ACCUMULATIONS FOR EACH MONTH COMPARED WITH THE 30-YEAR NORMAL.
THE TEMPERATURE IS THE AVERAGE OF THE DAILY MAXIMUM TEMPERATURE AT 16 STATIONS SIMILARLY, THE PRECIPITATION VALUES ARE THE WEIGHTED AVERAGE OF PRECIPITATION FROM 20 STATIONS.
COLUMBIA RIVER TREATY
OPERATING COMMITTEE
WINTER SEASON
TEMPERATURE AND PRECIPITATION
INDEXES
COLUMBIA RIVER
ABOVE THE DALLES, OREGON
1976 - 1977

CHART 3

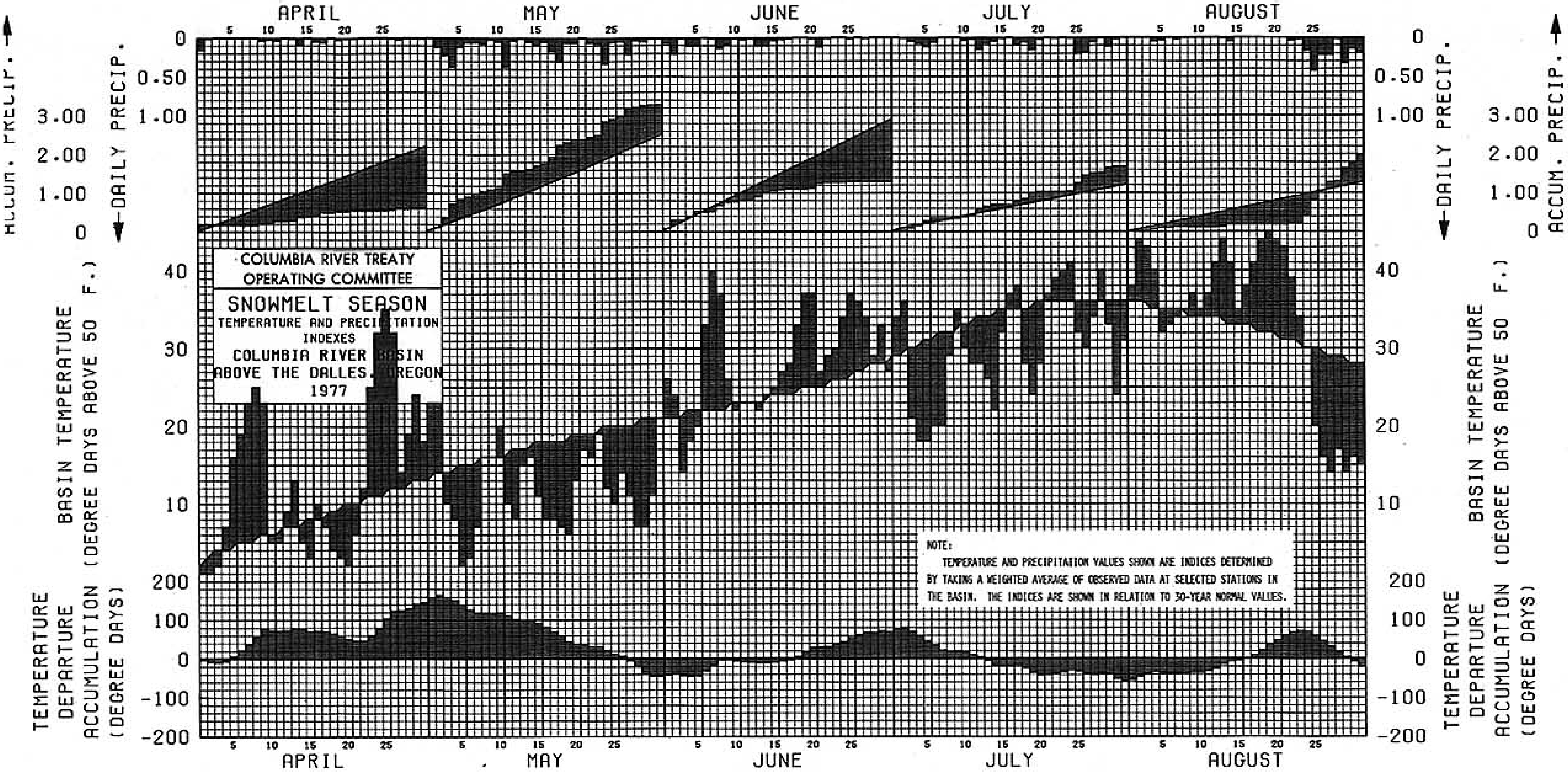
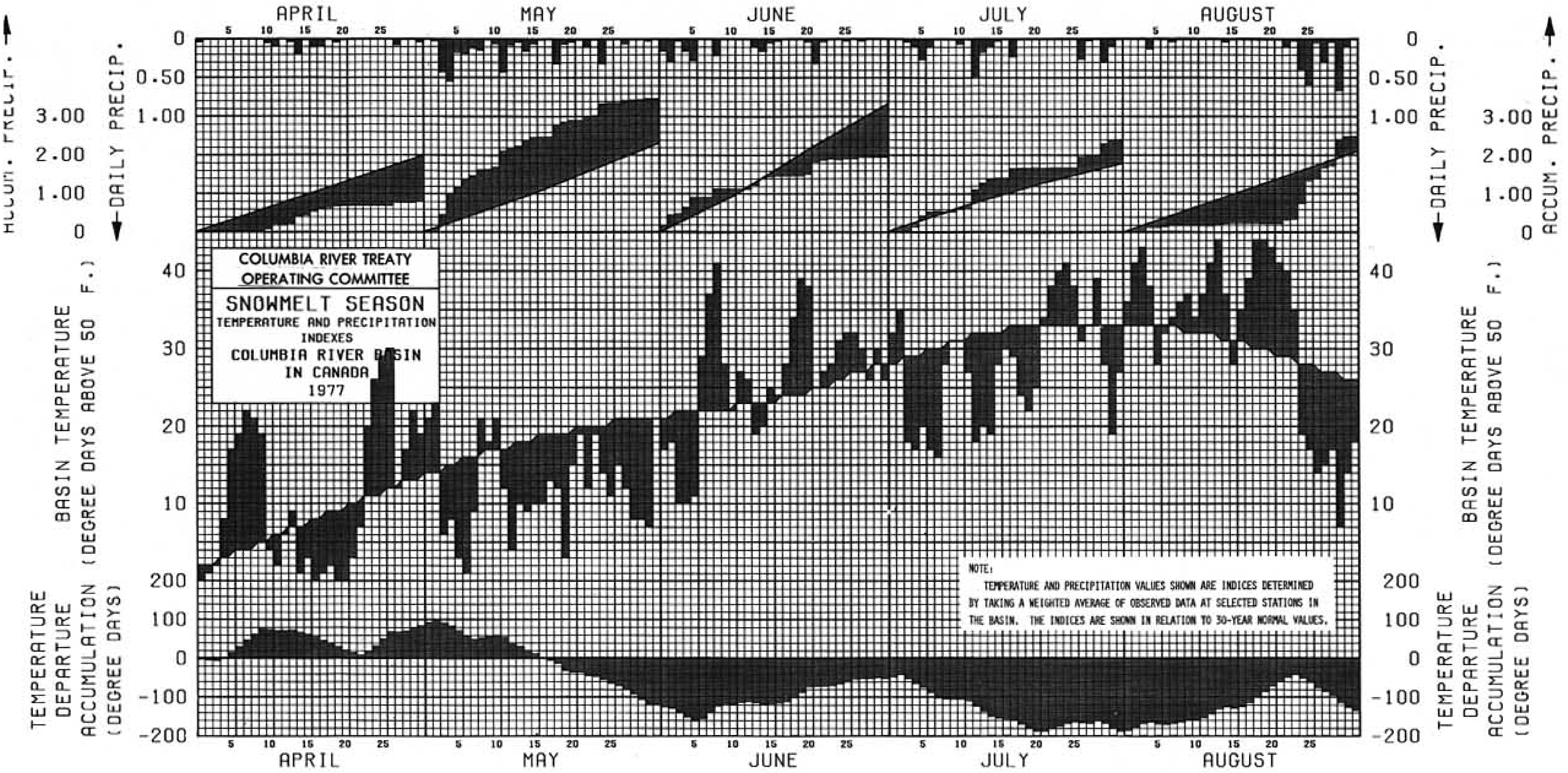
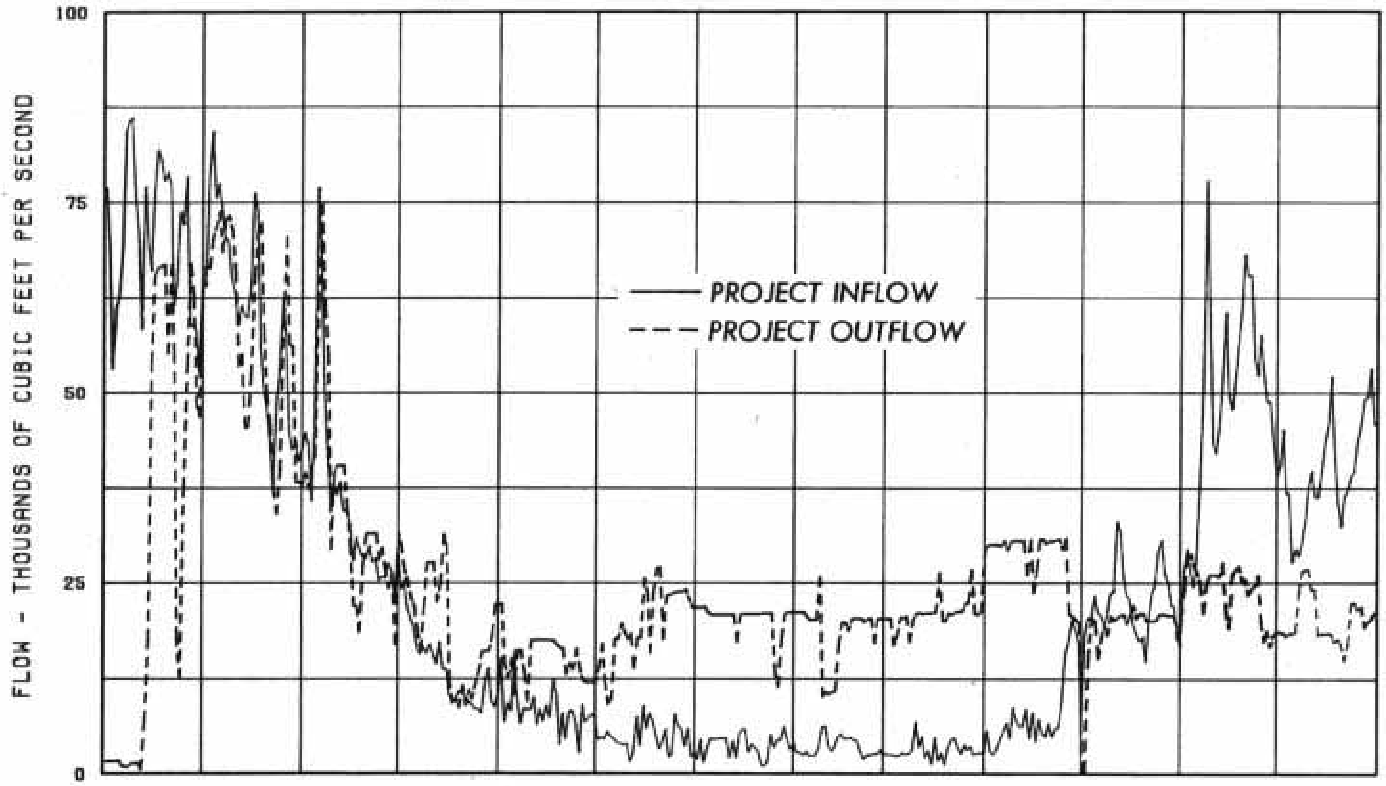
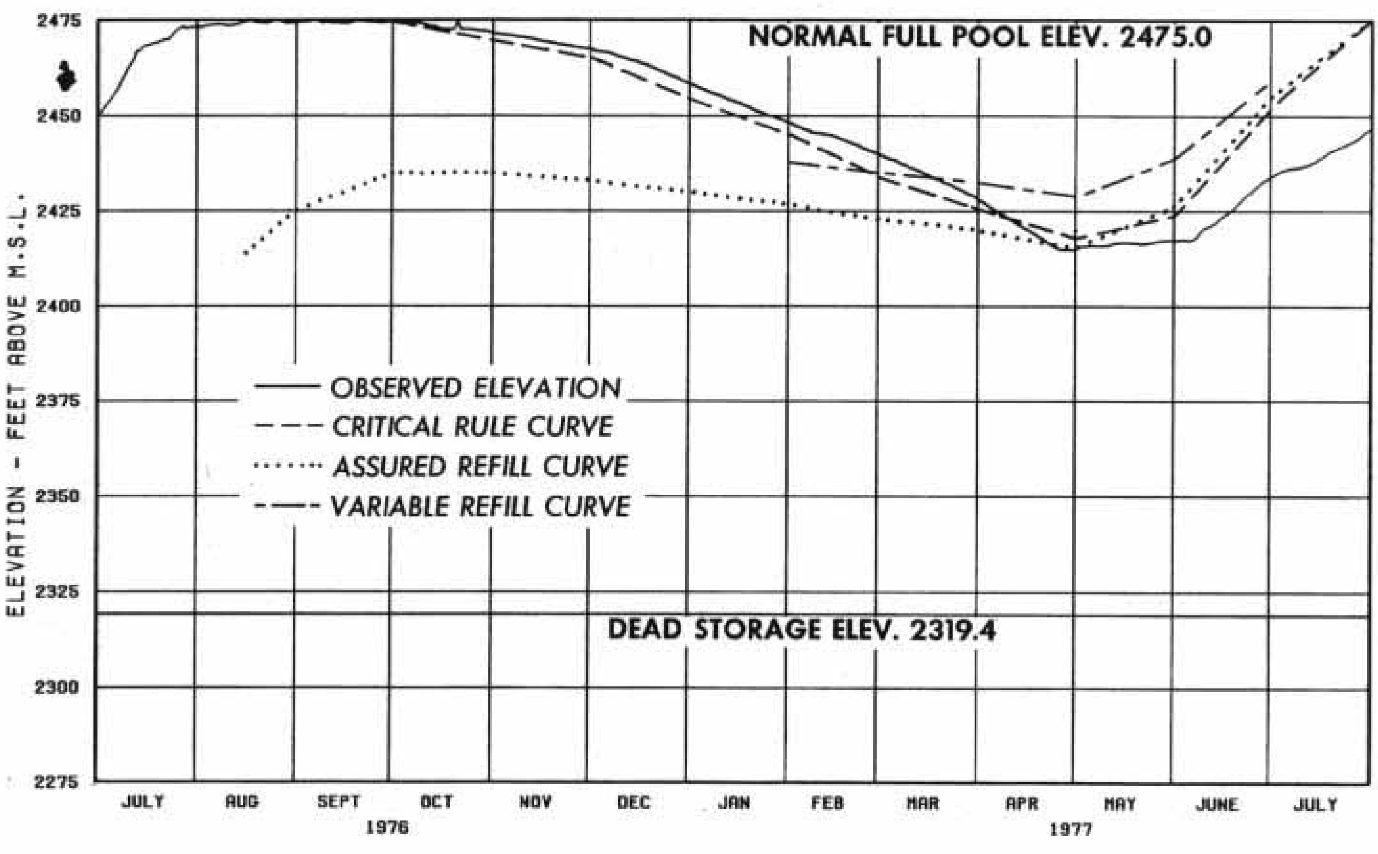

APRIL
MAY
JUNE
JULY
AUGUST
ACCUM. PRECIP.
DAILY PRECIP.
BASIN TEMPERATURE (DEGREE DAYS ABOVE 50 F.)
TEMPERATURE DEPARTURE ACCUMULATION (DEGREE DAYS)
COLUMBIA RIVER TREATY OPERATING COMMITTEE
SNOWMELT SEASON
TEMPERATURE AND PRECIPITATION INDEXES
COLUMBIA RIVER BASIN ABOVE THE DALLES, OREGON
1977
NOTE:
TEMPERATURE AND PRECIPITATION VALUES SHOWN ARE INDICES DETERMINED BY TAKING A WEIGHTED AVERAGE OF OBSERVED DATA AT SELECTED STATIONS IN THE BASIN. THE INDICES ARE SHOWN IN RELATION TO 30-YEAR NORMAL VALUES.

CHART 4

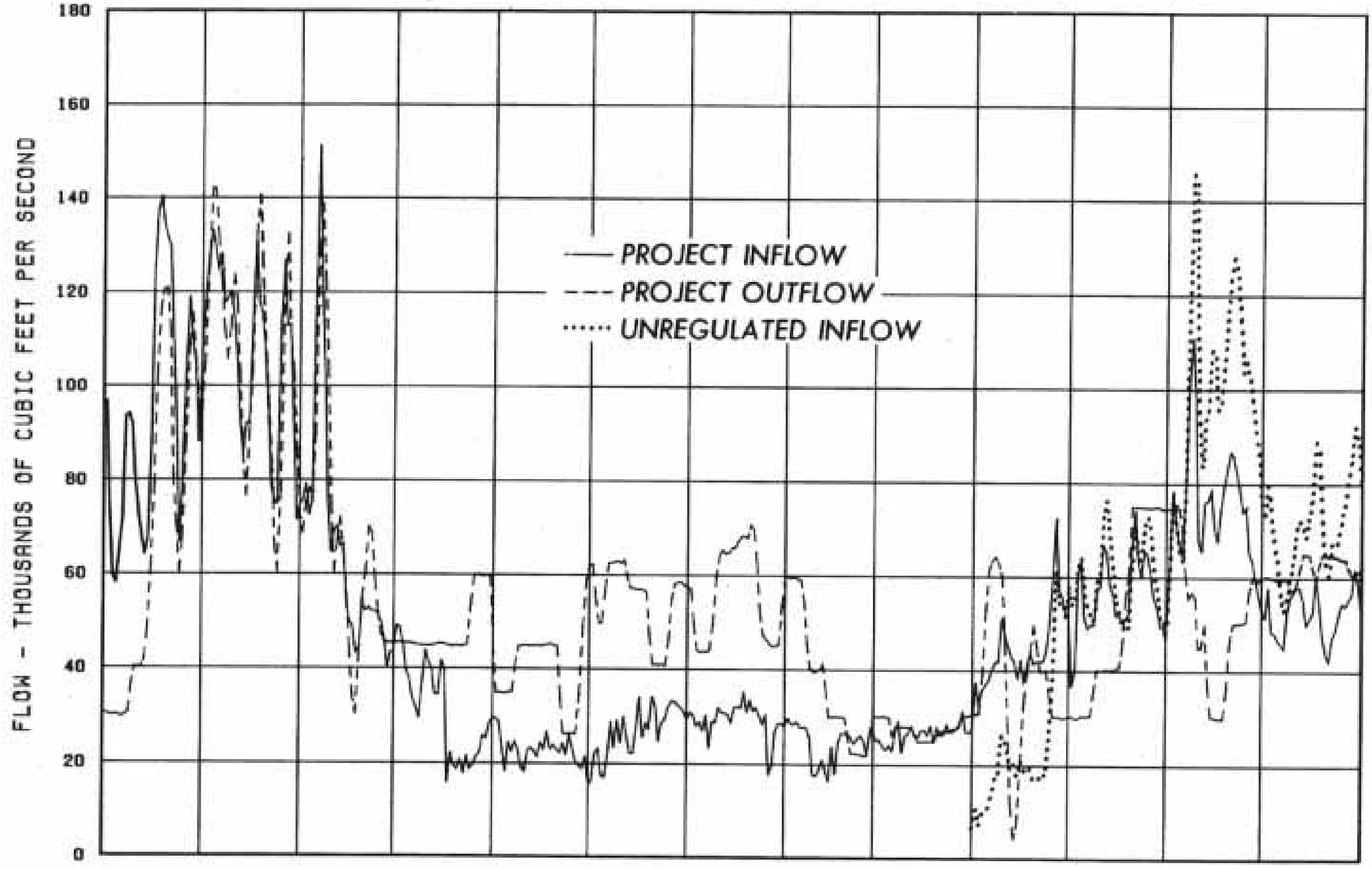

COLUMBIA RIVER TREATY OPERATING COMMITTEE
SNOWMELT SEASON
TEMPERATURE AND PRECIPITATION INDEXES
COLUMBIA RIVER BASIN IN CANADA
1977
APRIL
MAY
JUNE
JULY
AUGUST
ACCUM. PRECIP.
DAILY PRECIP.
BASIN TEMPERATURE (DEGREE DAYS ABOVE 50 F.)
TEMPERATURE DEPARTURE ACCUMULATION (DEGREE DAYS)
NOTE:
TEMPERATURE AND PRECIPITATION VALUES SHOWN ARE INDICES DETERMINED BY TAKING A WEIGHTED AVERAGE OF OBSERVED DATA AT SELECTED STATIONS IN THE BASIN. THE INDICES ARE SHOWN IN RELATION TO 30-YEAR NORMAL VALUES.

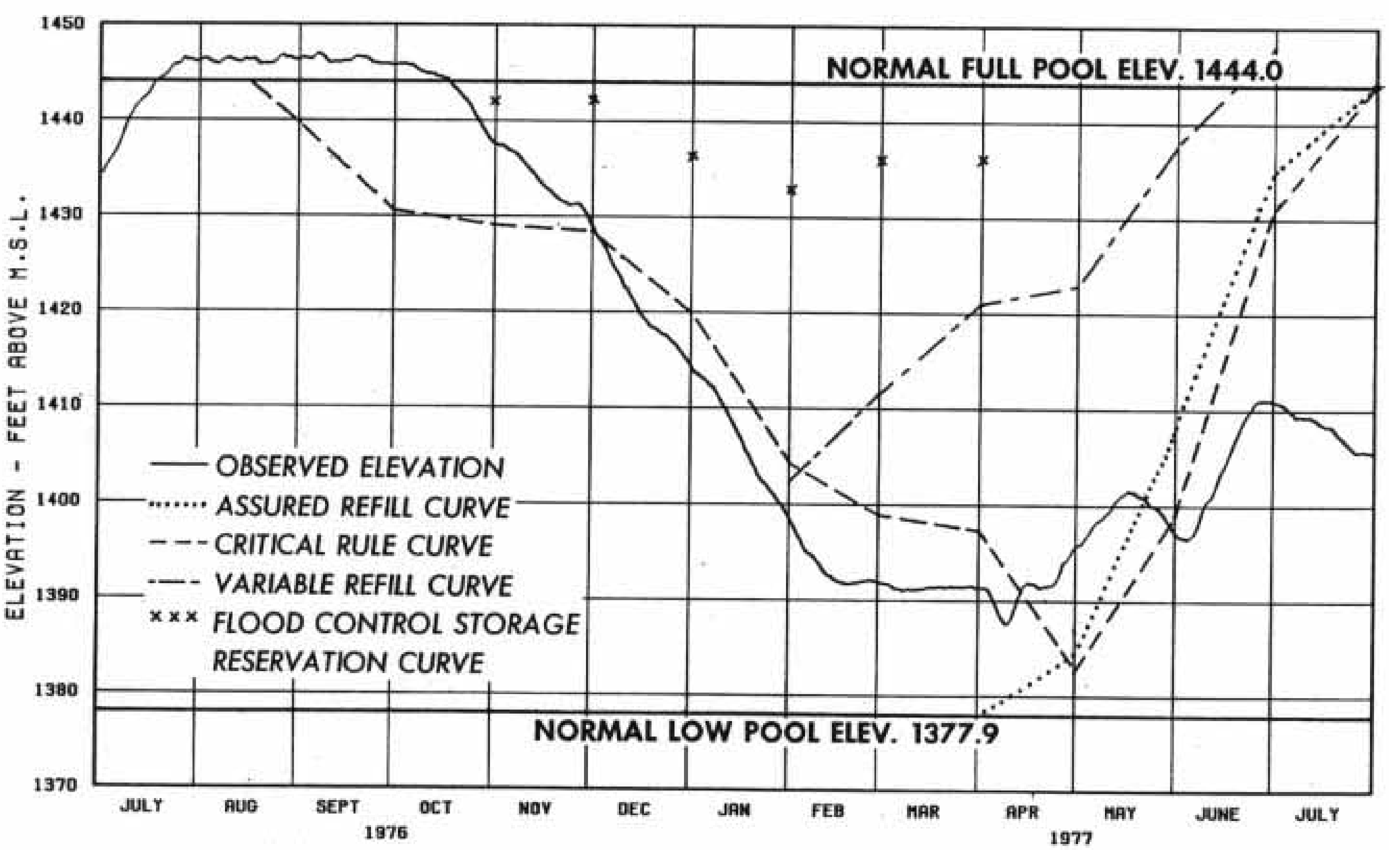
REGULATION OF MICA
1 JULY 1976 - 31 JULY 1977



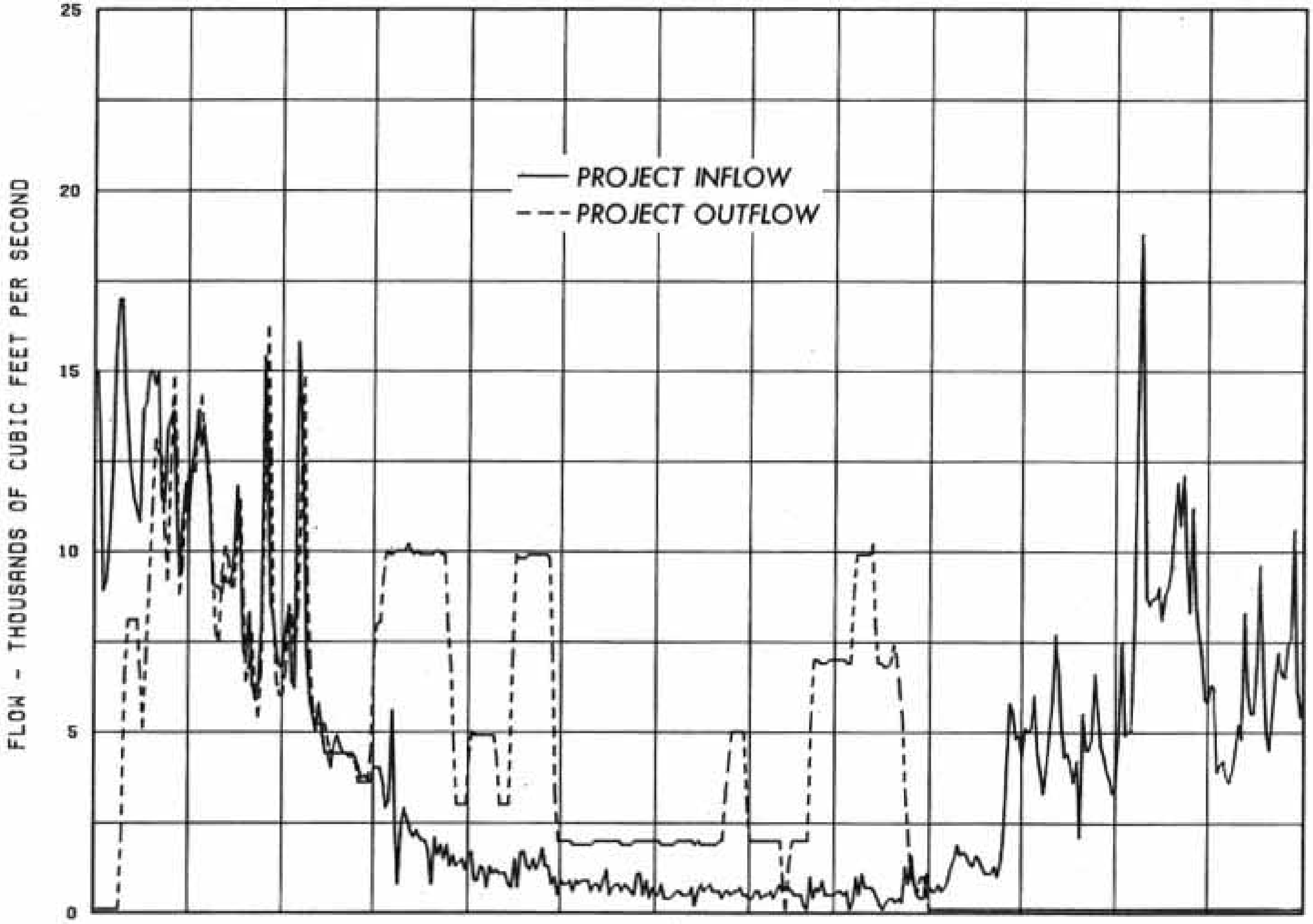


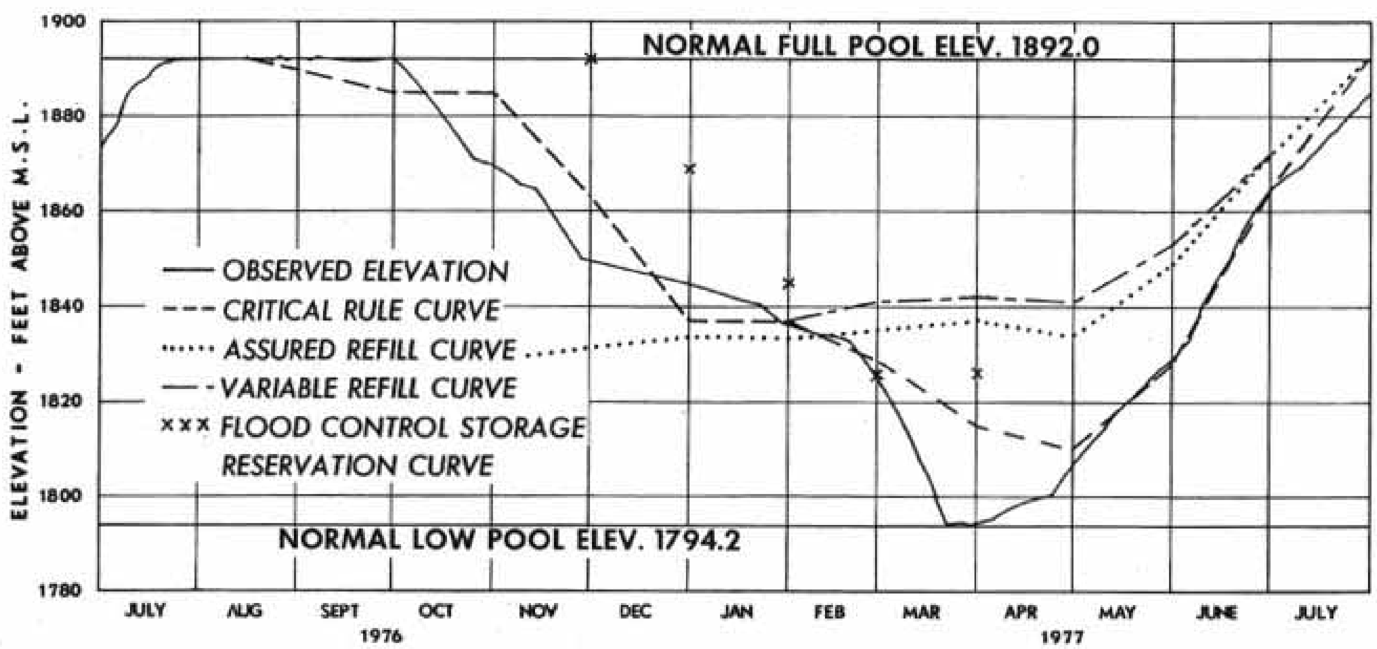
REGULATION OF ARROW
1 JULY 1976 - 31 JULY 1977



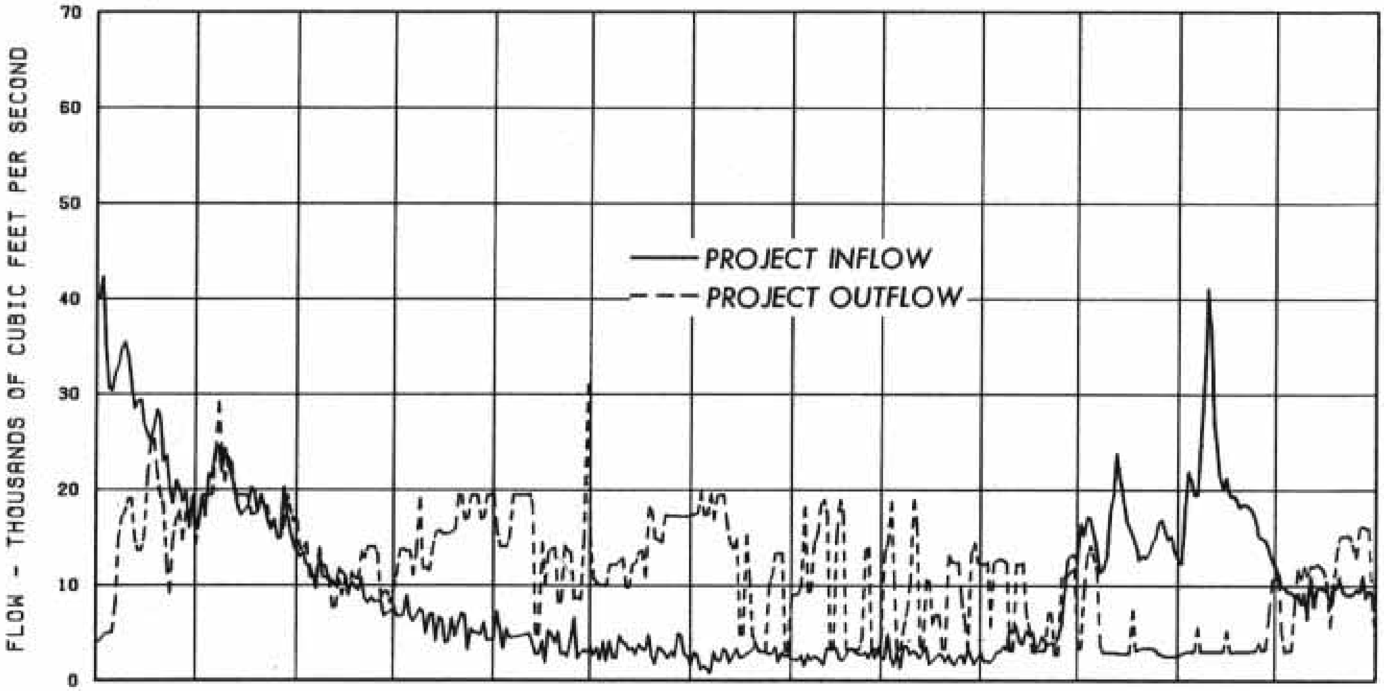


REGULATION OF DUNCAN
1 JULY 1976 - 31 JULY 1977





REGULATION OF LIBBY
1 JULY 1976 - 31 JULY 1977



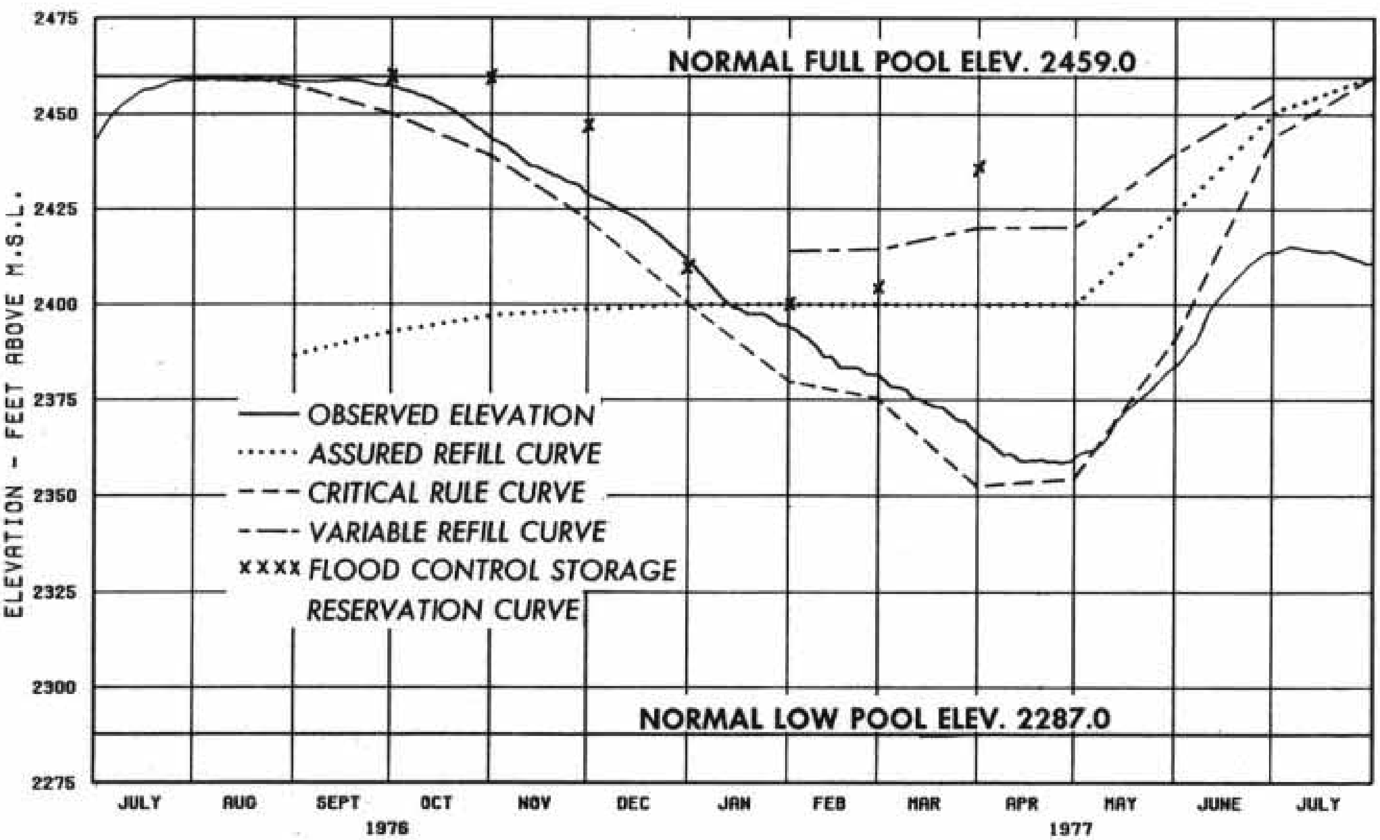


CHART 9
KOOTENAY LAKE

REGULATION OF KOOTENAY LAKE
1 JULY 1976 - 31 JULY 1977

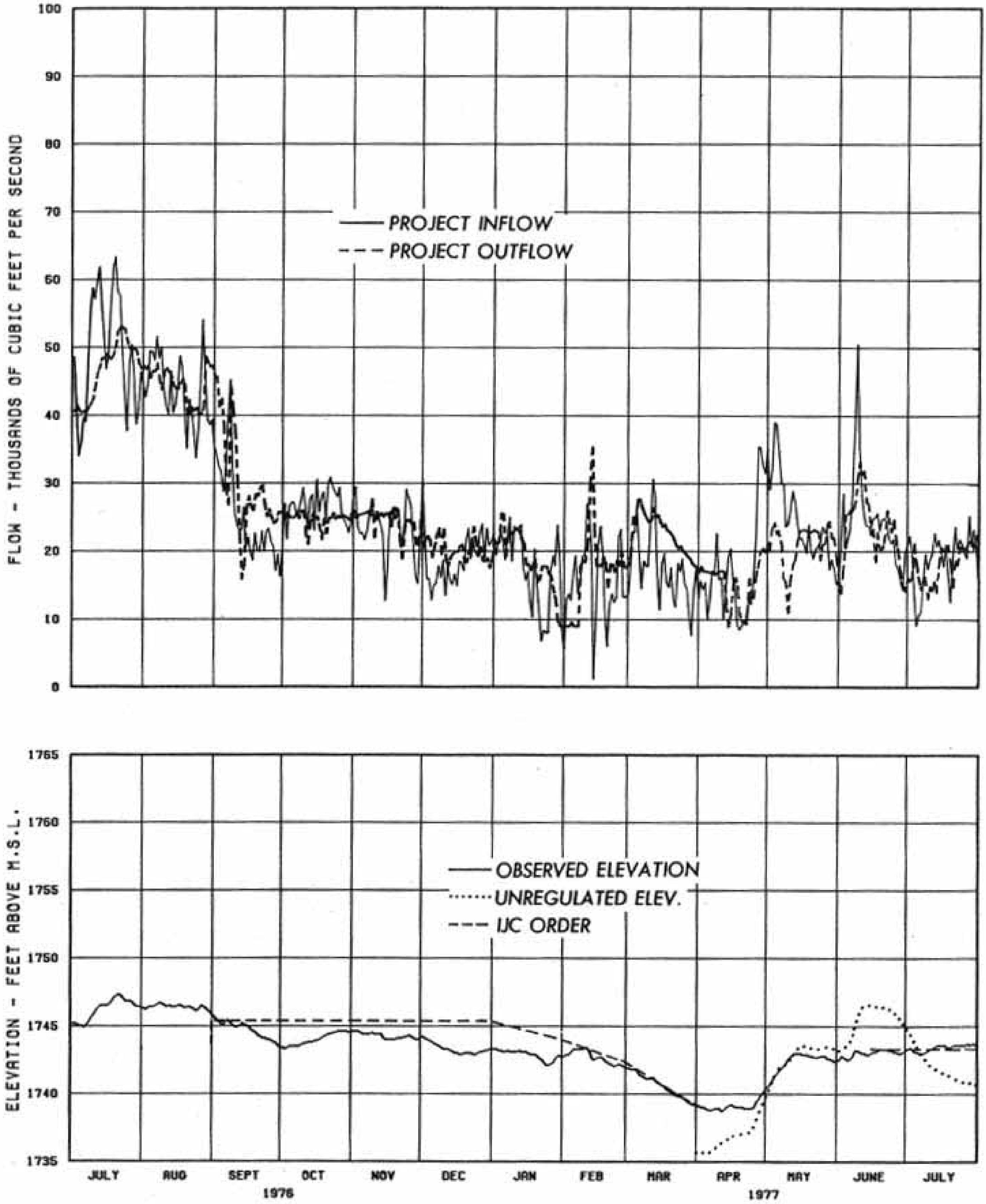
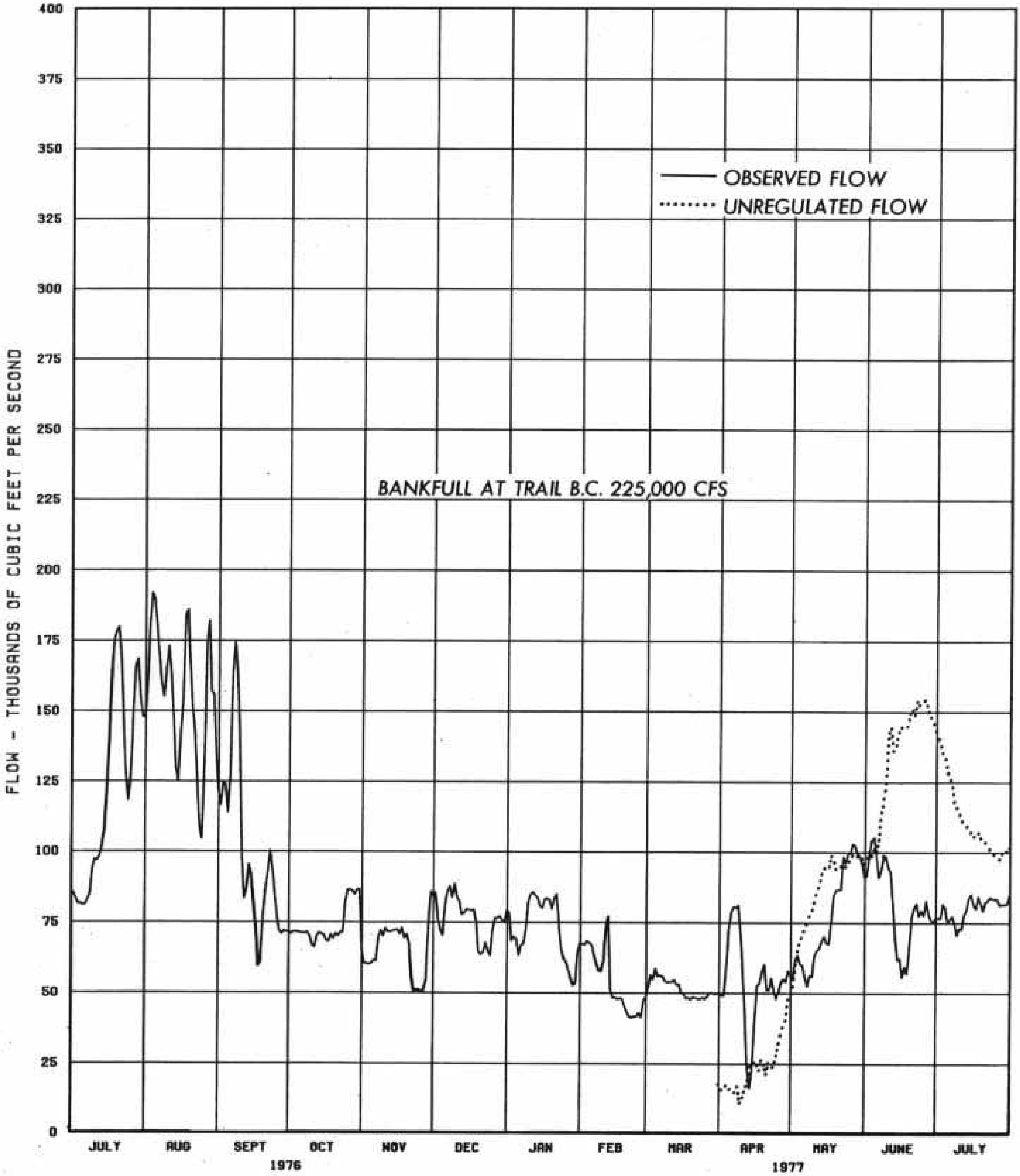


CHART 10
BIRCHBANK

COLUMBIA RIVER AT BIRCHBANK
1 JULY 1976 - 31 JULY 1977



REGULATION OF GRAND COULEE
1 JULY 1976 - 31 JULY 1977

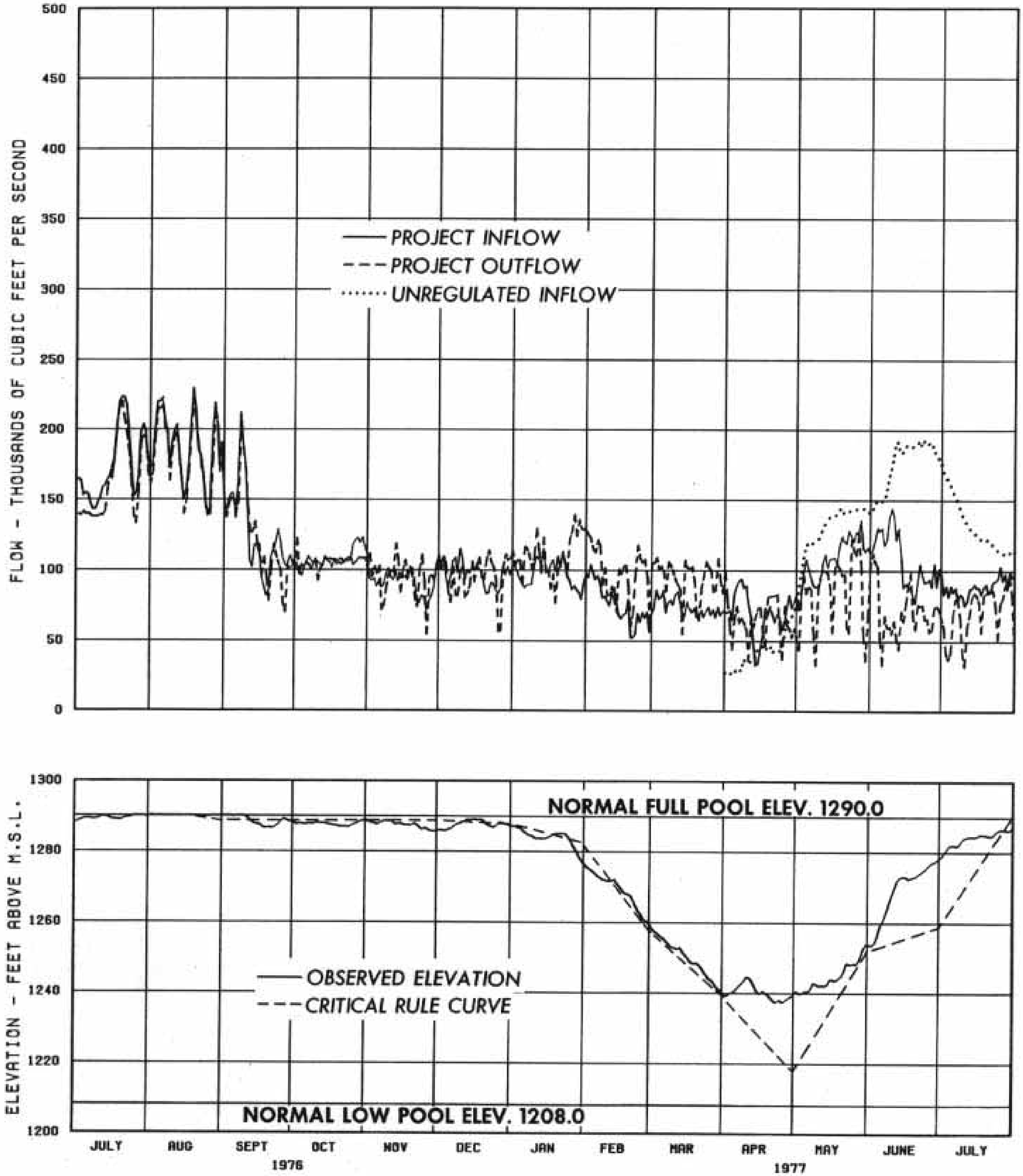
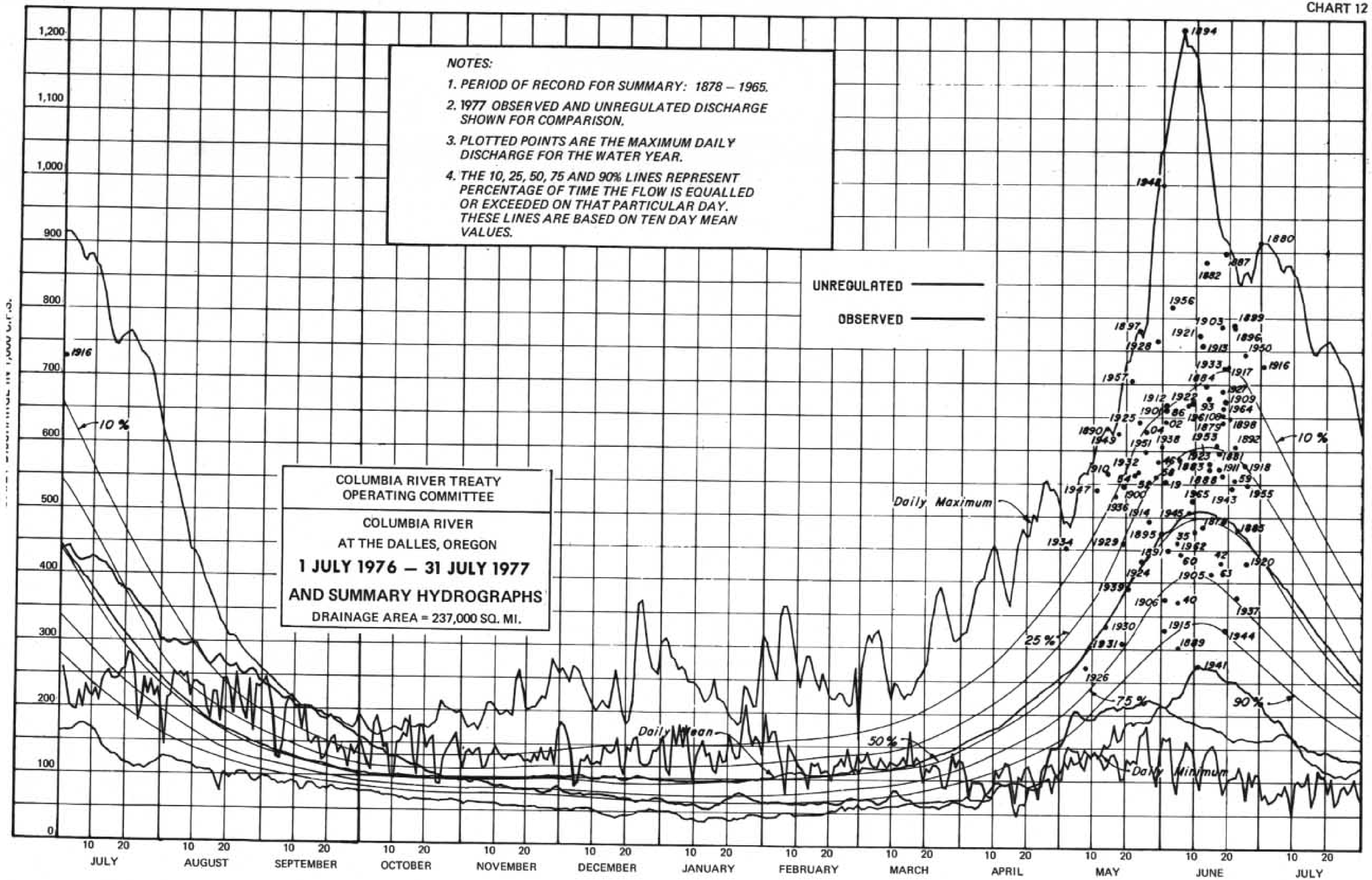
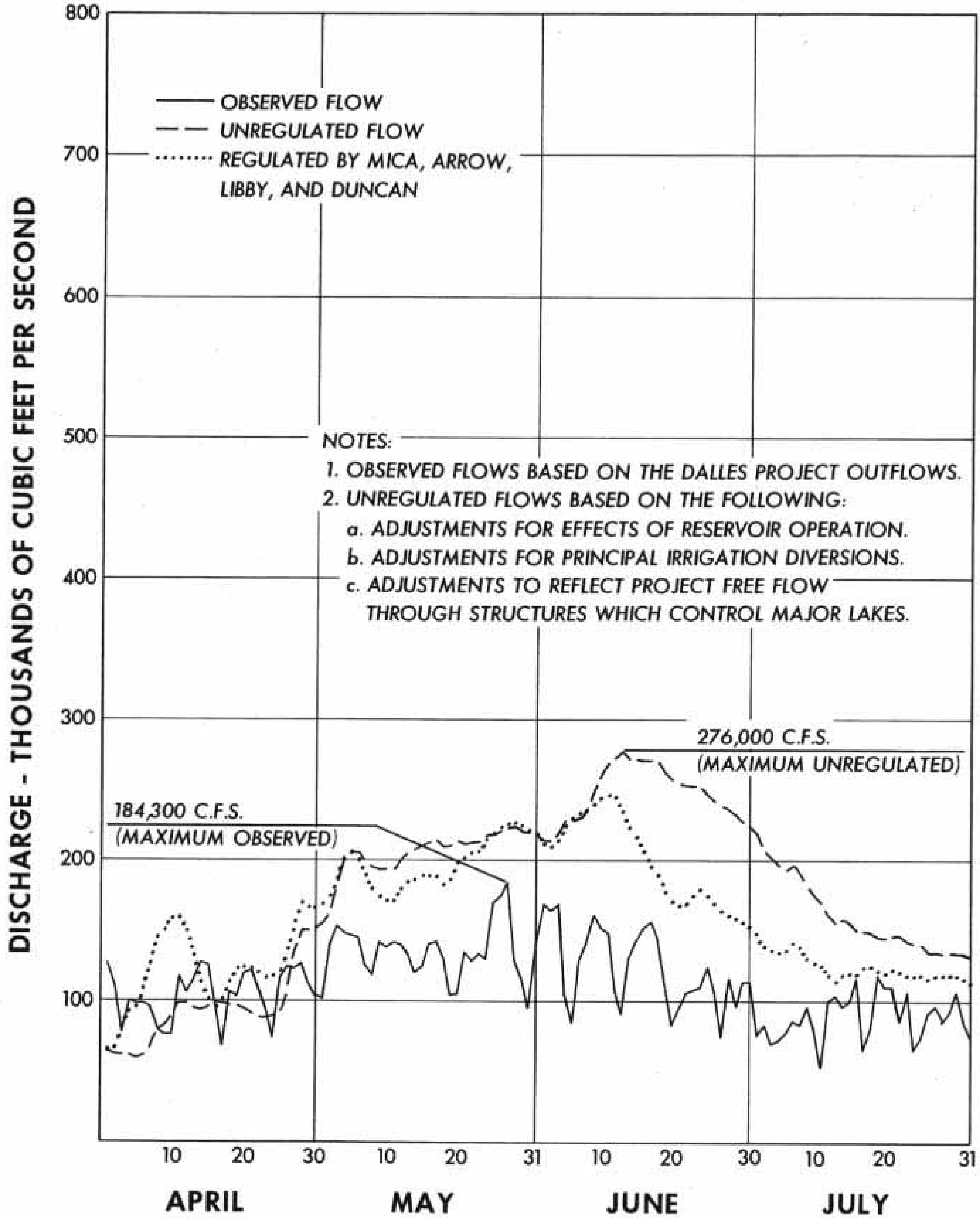


CHART 12


NOTES:
1. PERIOD OF RECORD FOR SUMMARY: 1878 – 1965.
2. 1977 OBSERVED AND UNREGULATED DISCHARGE SHOWN FOR COMPARISON.
3. PLOTTED POINTS ARE THE MAXIMUM DAILY DISCHARGE FOR THE WATER YEAR.
4. THE 10, 25, 50, 75 AND 90% LINES REPRESENT PERCENTAGE OF TIME THE FLOW IS EQUALLED OR EXCEEDED ON THAT PARTICULAR DAY. THESE LINES ARE BASED ON TEN DAY MEAN VALUES.
COLUMBIA RIVER TREATY
OPERATING COMMITTEE
COLUMBIA RIVER
AT THE DALLES, OREGON
1 JULY 1976 — 31 JULY 1977
AND SUMMARY HYDROGRAPHS
DRAINAGE AREA = 237,000 SQ. MI.
UNREGULATED
OBSERVED
Daily Maximum
Daily Mean
Daily Minimum
10 %
25 %
50 %
75 %
90 %
1,200
1,100
1,000
900
800
700
600
500
400
300
200
100
0
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY

COLUMBIA RIVER AT THE DALLES
1 APRIL 1977 - 31 JULY 1977



REFERENCES

The following documents governed the operation of the Columbia Treaty Projects during the period August 1, 1976, through July 31, 1977:

1. "Principles and Procedures for the Preparation and Use of Hydroelectric Operating Plans for Canadian Treaty Storage," dated 25 July 1967.

2. "Assured Operating Plan For Operating Year 1976-77", dated January 1972.

3. "Columbia River Treaty Detailed Operating Plan for Canadian Storage, 1 August 1976 through 31 July 1977," dated September 1976.

4. "Columbia River Treaty Flood Control Operating Plan," dated October 1972.